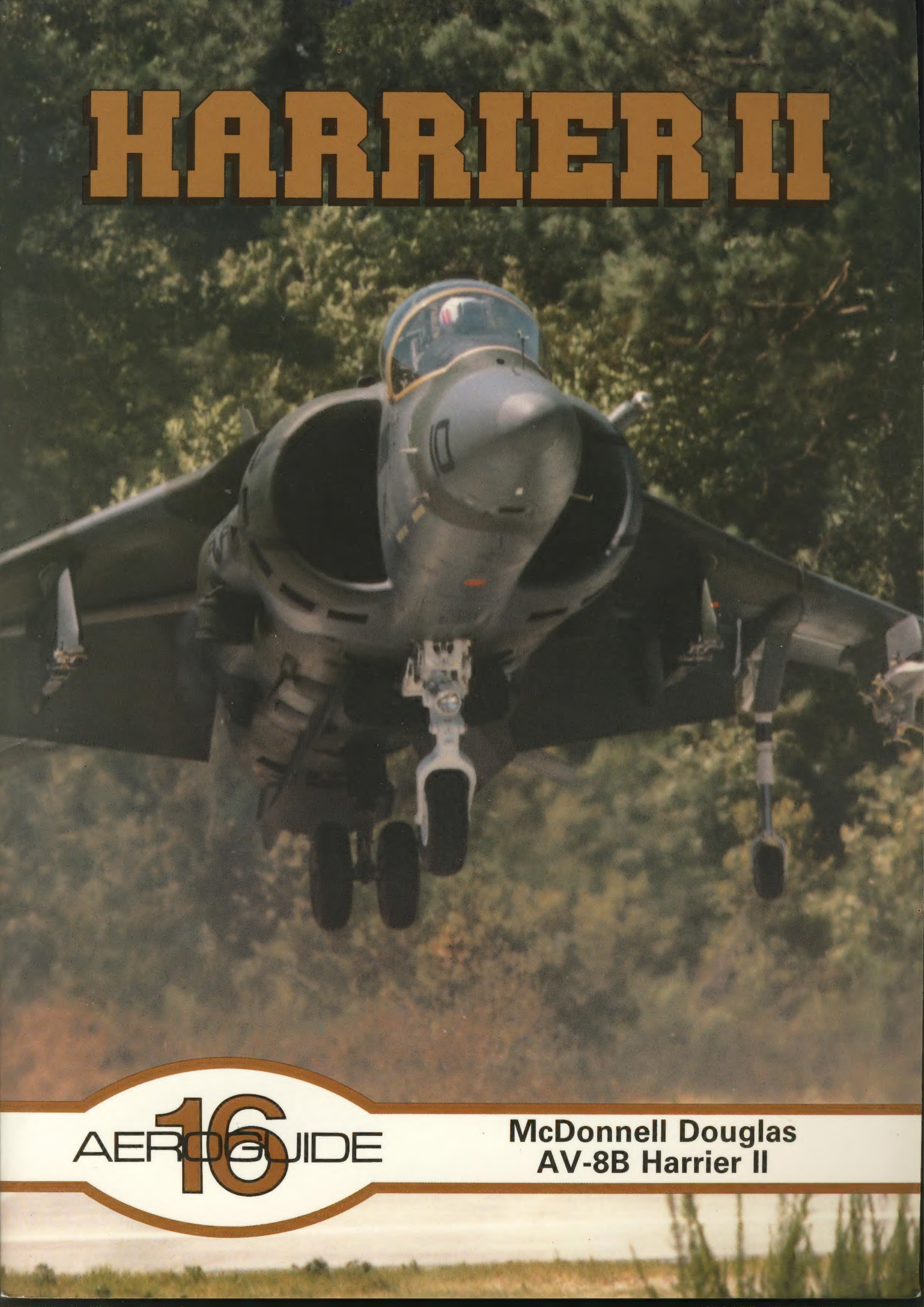
HARRIER II



AEROGUIDE 16

McDonnell Douglas AV-8B Harrier II

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McDONNELL DOUGLAS AV-8B
HARRIER II

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Cover photo: An AV-8B Harrier from VMA-331 'Bumblebees', photographed during off-base training exercises near MCAS Cherry Point, September 1985. The aircraft is painted in the newly introduced 'wrap-around' style camouflage. *McDonnell Douglas*

Back cover plate: A Harrier II from the training squadron VMAT-203 in the early camouflage scheme, late 1984.

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INTRODUCTION

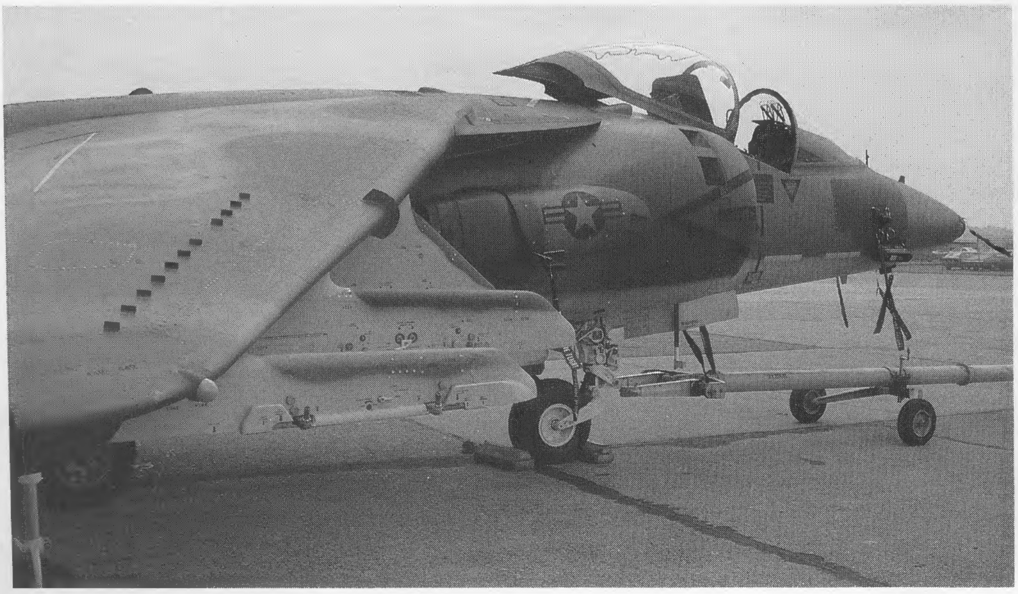
An aircraft that can take off vertically, hover, fly like a conventional aeroplane and then land in an area not much bigger than its own dimensions had been a dream since the beginning of manned flight, but it was not until September 1961 that the dream was fulfilled. At Dunsfold in Surrey, the Hawker P.1127 rose vertically from the ground, sniffed the air and coaxed itself gingerly forward into wing-borne flight. Twenty years later, nearly 5000 miles away in St Louis, Missouri, a similar scene was enacted with another aircraft.

An observer present at both events would have been struck by how much alike the principal actors were. The shoulder-mounted, slightly swept, downward-canted wings looked pretty much the same on both aircraft, although on the new machine they were clearly bigger. The two giant intakes were still there hugging the front fuselage, and tucked beneath the wing roots were the four swivelling jet nozzles. That curious undercarriage, its main gear arranged bicycle-fashion and with stalky outrigger wheels underneath the wings, was little different, and the strange nose-up, crouching attitude of the aircraft on the ground was very reminiscent of the P.1127. For sure the front end, with its big, domed canopy, wasn't familiar, nor were the funny angled fin strakes running along the fuselage undersides, but nothing else was much changed – right? Wrong. Ninety-five per cent wrong in fact.

The AV-8B Harrier II, without doubt, bears more than a passing resemblance to the Hawker P.1127, and has even more in common with the latter's offspring, the Hawker Siddeley Harrier, but almost everything about it is brand new; only the basic layout of the earlier aircraft has been retained, together with an improved version of its Rolls-Royce Pegasus vectored-thrust turbofan. The AV-8B is a brilliant compromise, taking a sound fundamental design and applying a quarter of a century of technological progress and fifteen years of operating experience to it. The new aircraft can carry more weapons, fly them further and offload them more accurately, with a reduced pilot workload; on the ground, it is easier to maintain, and its systems are said to be more reliable, improving even on the first-generation Harrier's impressive record. About the only way in which it is inferior to the older aircraft is that in 'clean' condition (*ie* with no external stores or pylons) it is some 40kt slower; on the other hand, an attack aircraft denuded of its warload is no real asset.

The Harrier II is in production right now for the United

Above: A pre-production AV-8B (foreground) flies in company with its progenitor, an AV-8A. The similarity in configuration of the two aircraft is striking, but the new aircraft is in fact a total redesign, with twice the capability of the original Harrier. *McDonnell Douglas*
Right: A production Harrier II in the markings of Marine Attack Training Squadron 203 (VMAT-203) and loaded with practice bombs waits to take off, September 1984. *McDonnell Douglas*
Below: A factory-fresh AV-8B on the ramp at the manufacturer's facility at St Louis, Missouri.



States Marine Corps and, in slightly modified form, for the Royal Air Force. Both services have long experience with V/STOL (vertical/short take-off and landing) operations. The aircraft is particularly suited to USMC requirements, since, as the 'sharp end' of an assault force, the Marines have a special need for immediate and available air support, which might not be forthcoming unless the troops on the ground happen to be close to the beach-head, with Navy carriers offshore, or conveniently near a friendly (or captured) air base with a long, paved strip. For the RAF the Harrier II (GR Mk 5) will also find itself close to the front line, in Western Europe, giving support at short notice to the men on the ground.

The advantages of V/STOL (or more relevantly STOVL, short take-off and vertical landing) have been well aired in print. They may be summarised in terms of basing flexibility. The commander has a wide range of choices open to him regarding where to site his Harrier force, both on land and at sea, which confers on the aircraft an unrivalled utilisation and sortie rate. He can thus inflict on the enemy a much greater weight of ordnance per unit of time, since air power will be very close at hand; already impressive for the GR.3/AV-8A, this weight/time ratio is considerably enhanced with the AV-8B owing to the vast array of weapons it can lift up in one go. Far less complicated back-up facilities are needed – particularly, in virgin territory, in terms of construction site equipment – in order to establish credible air support than is the case with CTOL (conventional take-off and landing) aircraft, thereby saving time, manpower and, if it matters, money. Vectored thrust, the key to jet-powered STOVL, has value in the air too, particularly in the realm of air combat manoeuvring, when the Harrier's flight path cannot with any certainty be predicted; with the AV-8B this capability is further enhanced because of the aircraft's larger wings (hence lower wing loading) and improved visibility out of the cockpit.

This volume will concentrate on the US side of the Harrier II picture and the aircraft's production for, and employment by, the Marine Corps; as these words are written new AV-8B squadrons are steadily 'coming on line', so the story has in that sense only just begun, whilst the Royal Air Force's first GR Mk 5 squadron has not yet been formed. For a discussion of the design and development of the original Harrier, readers are referred to AEROGUIDE 12.

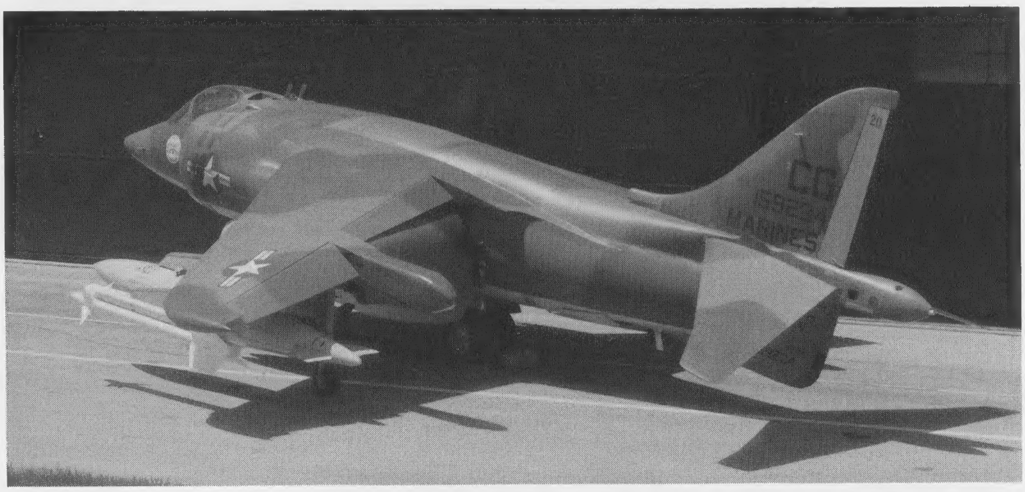
DESIGN & DEVELOPMENT

American interest in the Harrier concept can be traced back to the beginnings of V/STOL operations in Great Britain, and the production of the aircraft in the United States was first mooted in the early 1970s, when Hawker Siddeley signed up McDonnell Aircraft (now a division of the McDonnell Douglas Corporation) as a manufacturing licensee for any Harriers that might be ordered for US service. Although in the event the Marine Corps' first Harriers, designated AV-8A, were all built in Britain because it was cheaper that way, the partnership between Kingston and St Louis has continued to blossom up to the present day.

The US Marines have always been enthusiastic about the Harrier, but have long recognised in the aircraft shortcomings which would need to be looked at to make it match their requirements exactly; the Royal Air Force, for whom the aircraft was built in the first place, also recognised shortcomings, but a somewhat different set. In particular, the Marine Corps' AV-8A didn't really carry enough in the way of ordnance, and didn't have the range to take what it could carry far enough; at the same time, there clearly was, or would soon be, a requirement for a successor which, if the US Navy's attention was to be attracted as well, might have to be supersonic. Across the Atlantic, the Royal Air Force, though interested of course in a new V/STOL aircraft, was more immediately concerned about a deal that could see their existing Harriers fitted with big new wings that could not only tote up to ten pylons per aircraft but would also give the Harrier a formidable turn rate and hence make it an agile dog-fighter; the USMC's plans would produce a first-rate 'bomb truck', but one which would be a bit sluggish.

The first practical step in upgrading the Harrier concept took the form of the AV-16 design ('twice an AV-8'), sometimes called the Advanced Harrier, of 1973, which used the existing fuselage and tail arrangement, added a larger, supercritical wing and somehow squeezed in a Pegasus 15 engine which would give 25,000lb of thrust, roughly 20 per cent more than the Pegasus of the AV-8A. With enlarged intakes and a stepped-up cockpit, the AV-16 represented a remarkable improvement, but the cost of the project – and especially the financial burden imposed by developing the new engine, which itself might require upwards of $1500 million – more or less put it out of court straightaway. The death knell came when the US Navy finally decided to put its weight behind the futuristic, thrust-augmented wing Rockwell XFV-12 (which, as it happened, never got off the floor).

With the AV-16 project on the scrap heap and the US Marines still needing a better Harrier, McDonnell took the logical line of reasoning that if nothing much could be done to the existing Pegasus engine then something



Right and below: Some of the new features of the AV-8B concept were demonstrated in mock-up form on a redundant AV-8A airframe and shown for the first time in August 1975. The modified main intakes, big wing, extra stores pylons and underfuselage lift-improvement devices (LIDs) are clearly seen in these two photos. The fuselage, tail surfaces and engine nozzles were not modified for this non-flying replica, which also retained its VMA-231 codes. *McDonnell Douglas*

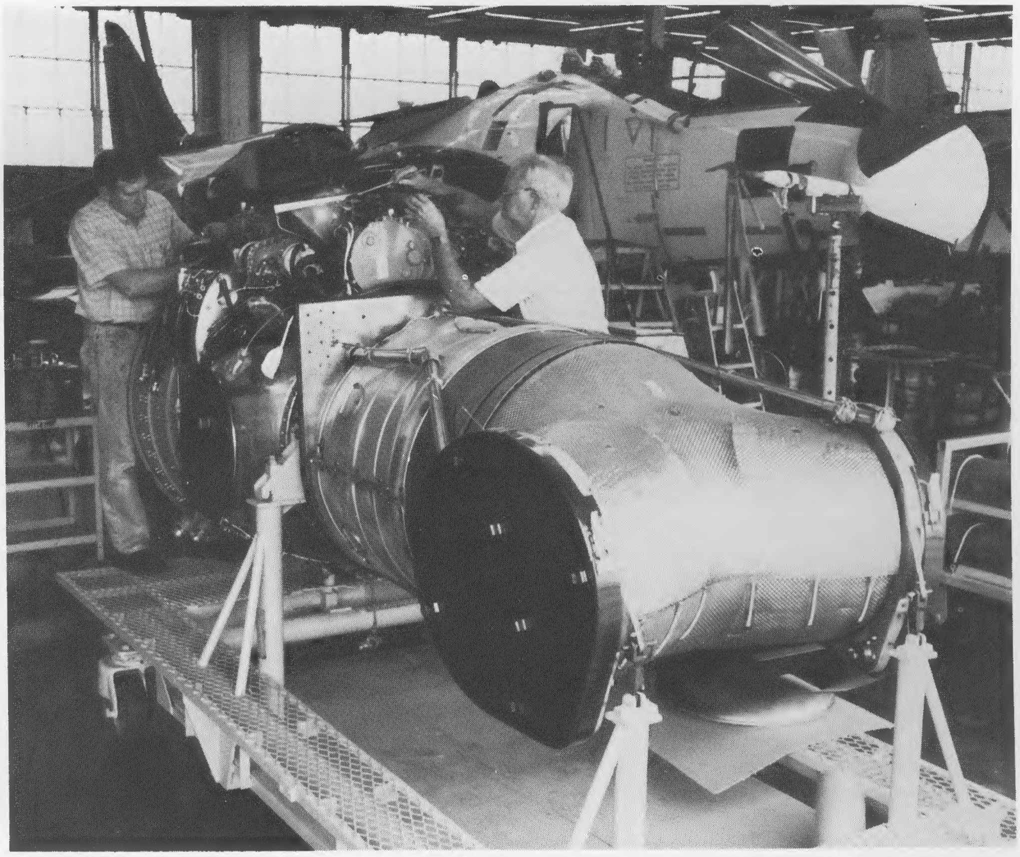
Right: Testing the AV-8B concept in earnest got under way in 1976 when another AV-8A, BuNo 158385, fitted with the new wing, LIDs and intakes, was despatched to NASA's Ames Research Center in California. Here it was mounted on a rig and its engine run in extensive trials to investigate jet efflux characteristics; it later spent over 300 hours in the huge wind tunnel at the Center. *McDonnell Douglas*

Below: The first YAV-8B, 158394, seen just before its maiden flight, autumn 1978. Like the two non-flying demonstrators, this aircraft and its sister-prototype, 158395, were converted AV-8As, lacking the raised cockpit and lengthened rear fuselage of later Harrier IIs. *McDonnell Douglas*

would have to be done about the airframe. Every detail of the AV-8A was scrutinised to see how the structure and design could be improved. Clearly, giving the aircraft more range would require more fuel, and giving it a bigger punch would need more pylons; both would call for greater airframe strength and both, if conventional construction materials were to be used, would drive up weight. But the engine was not to be uprated, and so the only answer was to keep the empty weight of the new machine down to that of the AV-8A, or as close to this as possible, while at the same time working in every thrust-enhancing device that could be thought up.

McDonnell designers knew how this could be achieved, but some brave decisions had to be made nevertheless. The vital component was the wing. If metal construction were to be rejected in favour of new carbon fibre (graphite/epoxy) composite materials, the new wing could have twice the strength of the old Harrier wing and still show a

Left top: Lift-off for the first full-scale development Harrier II, November 1981. *McDonnell Douglas*
Left bottom: FSD 1 (foreground), 4 (in pale grey finish) and 3 at St Louis, March 1982. FSD 4, structurally incomplete here, shows the double row of intake 'blow in' doors and 'zero-scarf' front nozzles particularly well. *McDonnell Douglas*
Right: An F402-RR-406 Pegasus engine is checked out for its new home, the second full-scale development AV-8B seen in the background. Of the same basic dimensions as the -402 powerplant installed in the AV-8A, the 'interim' -404 featured several advances, including increased hot-section life, improved reliability and easier maintenance; further improvements have resulted in the -406 model for production aircraft. *McDonnell Douglas*



weight saving. The theory, however, had hitherto not been applied to so large and vital a structure as a complete wing. Composites could also be used elsewhere, and in total could represent over a quarter of the empty airframe weight – a saving, it was estimated, of almost 500lb. In addition, a wing of supercritical aerofoil section would itself permit much more internal volume (and so carry much more fuel) and give greater efficiency in the air. The second area of study concerned possible ways of improving the low-speed handling qualities of the aircraft, in particular during take-off. The main intakes could be revamped to give a better airflow and reduced drag, and the front nozzles could be recontoured to 'zero-scarf' shape, resulting in a more concentrated and thus more effective efflux. Further back, gigantic, single-slotted flaps would enhance lift, and beneath the fuselage huge longitudinal strakes would get every last ounce of thrust from the vertically directed exhaust to work for its living and ensure the best possible 'ground cushion' for VTOL operations.

These new features were demonstrated in mock-up form on a surplus AV-8A, which was shown off for the first time in August 1975. A concentrated research programme to test the innovations was initiated, another AV-8A being fitted out as a non-flying prototype and submitted to what were in effect wind tunnel tests in order to determine the optimum aerodynamic arrangements and the best type of nozzle shape. The success of these experiments prompted the US Defense Systems Acquisition Review Council (DSARC) to finalise a contract with McDonnell Douglas to convert a pair of AV-8As into YAV-8B flying prototypes, and the show was on the road.

The two YAV-8Bs, which incorporated almost all the new features that were to be adopted for the production Harrier II save the redesigned front end, were put together in remarkably short order and the first one was flying by the end of 1978. Its performance exceeded expectations by a handsome margin, so much so that an investigation quickly got under way to see how many of the changes could be retrofitted into the existing AV-8A fleet, especially whether the new ventral strakes (or 'LIDs', for lift-improvement devices) would be appropriate. They were, and an upgrading programme was launched, which also included the fitting of RWR (radar warning receivers), low-voltage formation lights, chaff and flare dispensers and an on-board oxygen generating system (OBOGS). The modified aircraft were redesignated AV-8C.

The second YAV-8B crashed following an engine flame-out after about a year's flying, but by this time nobody needed any further convincing that the AV-8B would represent a startling improvement over the original Harrier – at least, nobody who knew anything about Harriers – and the building from scratch of four full-scale development (FSD, or pre-production) aircraft was well under way. The actual contract authorising McDonnell Douglas to proceed to this stage, hinted at when the two YAV-8Bs were given the go-ahead, was sealed in April 1979. However, politics intervened.

The vociferous anti-Harrier (and generally pro-F-18 Hornet) lobby began to agitate about 'foreign' military aircraft, overlooking the fact that by this time the programme was more American than British. The manufacturers kept a low profile while the politicians thrashed out the arguments for and against. Finally, President Carter passed the buck to the British Ministry of Defence, indicating that the AV-8B project could go ahead only if an export customer could be found (without, apparently, specifying how many aircraft such a deal would have to embrace). Doubtless the people at BAe Kingston blanched somewhat on learning this, since the finger was being pointed quite directly at the Royal Air Force – the required 'export' customer for the aircraft that they at Kingston had invented! Actually, BAe was in an impossible position, as was the RAF, and in the final analysis the decision was made for them. The RAF still wanted its re-winged Harrier, and BAe had shown that it

could produce precisely what was required, and better, but the UK government's attitude was lukewarm since it wished to cut defence expenditure. Not wanting to push its luck with an apparent loser, BAe opted for next best and decided to keep its hand in with the AV-8B programme; as one member of the Kingston staff neatly put it, '30 per cent of something is a lot better than 100 per cent of nothing!'. The AV-8B was ordered for the Royal Air Force in the summer of 1981.

Assembly work on the four FSD aircraft at St Louis, continuing the while with no crushing urgency, thus received new impetus. The two-year delay, whilst aggravating and also costly, at least afforded an opportunity to fine-tune the design, especially the engine. The powerplant was originally to have been the Rolls-Royce F402-RR-404 (Pegasus 11, or Mk 104, in British terminology), delivering 21,500lb of thrust and to all intents and purposes identical to that installed in the Royal Navy's Sea Harrier. Now, however, quite a lot had been done to increase its reliability and bring down its running costs, so much so that the designation F402-RR-406 (Pegasus 11-21E, or Mk 105) has been applied and another 500lb of thrust been gained.

FSD No 1 flew for the first time late in 1981; by April the following year FSD 2 and 3 were in the air; and FSD 4 went up in June 1983. Various design details have been modified as a result of the flight tests, especially those undertaken at the Naval Air Test Center at Patuxent River during Navy Preliminary Evaluation (NPE) and, later, Initial Operational Test and Evaluation (IOT&E). Most notably, the double row of auxiliary 'blow-in' doors down each main intake has been abandoned, and replaced by a single row much like that of the original Harrier in appearance, whilst the addition of leading-edge wing root extensions (LERX) has gone some way towards meeting the RAF's requirement for improved turn rates. Following normal procedure, each FSD aircraft was charged with a specific set of tasks. The first aircraft, Bureau Number (BuNo) 161396, was used for preliminary evaluation and the exploration of general handling qualities, including flight flutter tests as the performance envelope was gradually expanded. FSD 2's main jobs were to test the powerplant and the structural integrity (with both air and ground loads) of the airframe; serialled 161397, it was painted in a high-visibility red, white, black and gold colour scheme. No 161398 was the bomb-toting Harrier FSD 3 aircraft, fitted out with a full suite of avionics to demonstrate and calibrate the type's weapons integration; originally painted, like No 1, in camouflage, it for a time bore dramatic swathes of orange and white across its flying surfaces in connection with spin recovery trials (which were originally pencilled in as being part of FSD 2's programme). The fourth pre-production aircraft, No 161399, which was finished in a two-tone, low-visibility pale grey paint scheme with medium grey markings, was a non-instrumented machine used principally for assessing reliability and maintenance demands, establishing production acceptance criteria, verifying electromagnetic compatibility and training aircrew. The FSD Harrier IIs undertook a wide range of other important trials, for which task-specific instrumentation was added or removed as required.

With the FSD aircraft going about their duties, attention on the shop floor at St Louis began to focus on the twelve 'pilot production' AV-8Bs, funding for which was authorised for Fiscal Year (FY) 1982. The first of the twelve flew in August 1983. This phase of the programme was well under way when the NATC recommendations came through, which explains why early production Harrier IIs had the double row of blow-in doors around their main intakes. Other technologies were worked in as the aircraft began to reach USMC squadron status. The F402-RR-406 powerplant, for example, was not quite ready in time to equip the first few airframes, which were consequently fitted with the -404 referred to earlier.

The Harrier II work-split between McDonnell Douglas and British Aerospace is complex and differs according to the customer for which the aircraft are being produced. Marine Corps AV-8Bs show a 60–40 share-out in favour of the US manufacturer for the airframe content, with a

Below: The first of twenty-eight two-seat TAV-8B trainers, photographed during its maiden flight in October 1986. Apart from the two-place cockpit in the extended front fuselage, the TAV-8B also features an enlarged tail fin, with the rudder actuator now in an external fairing. *McDonnell Douglas*

Top: FSD 3 leaves the ground for the first time, April 1982, affording a good view of the large ventral strakes. *McDonnell Douglas*
Above: The RAF version of the AV-8B is designated Harrier GR Mk 5, and the first aircraft, seen here, flew on 30 April 1985. Sixty-two GR.5s are officially on order, but it has been reported that the purchase of long-lead items for a further 27 machines has been sanctioned. *British Aerospace*

slightly closer ratio for the RAF's GR.5s; the assembly of aircraft for export customers – Spain has already ordered a dozen – will be split 75–25 in favour of St Louis. Rolls-Royce retains the greater production share of its Pegasus for the AV-8B programme, only a 25 per cent interest going to Pratt & Whitney in the United States, and that solely for Marine Corps aircraft. Systems and equipment show a 75–25 ratio US–GB, again modified slightly for the RAF order and export aircraft. In terms of airframe components, McDonnell Douglas builds the forward fuselage, wing and tailplanes and BAe Kingston the rest, although BAe Warton Division produces the metal fin and composite rudder and the composite tailplanes for the GR.5s. The total AV-8B procurement at the time of writing is for 406 machines, comprising 328 plus four FSD aircraft in the USA, 62 for the RAF and the twelve Spanish Harrier IIs. Included in the US batches are 28 TAV-8B trainers, the first of which flew in October 1986.

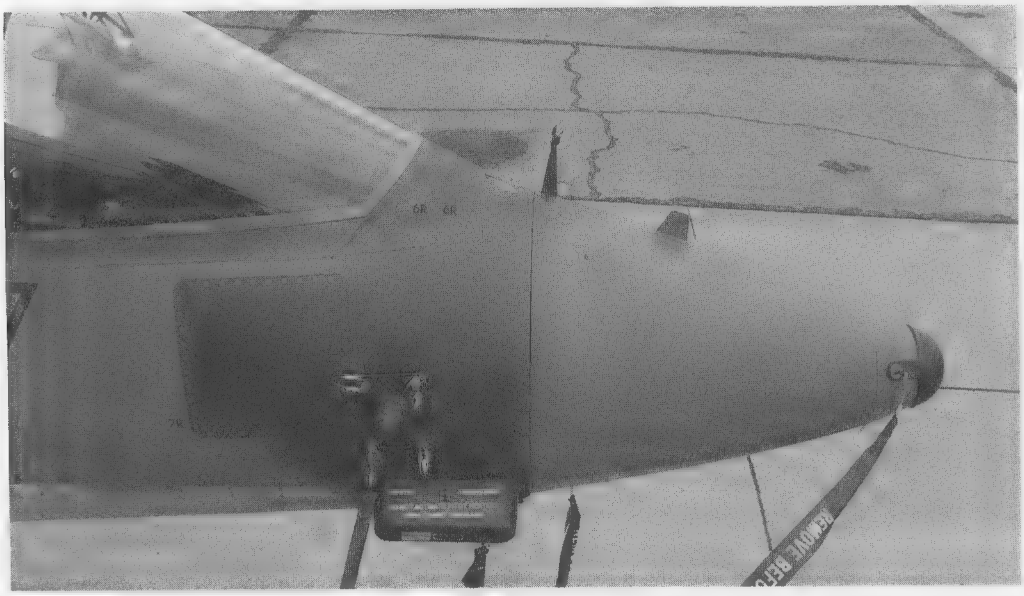
Plans to upgrade and refit the Harrier II are already well in hand. An early modification is the integration of a digital engine control system (DECS), developed by Dowty & Smiths Industries Controls and Rolls-Royce, in collaboration with St Louis. In essence, this equipment automatically checks and adjusts the settings for engine speed, acceleration, temperature and pressure, tasks which previously had to be undertaken manually by the pilot. The system was test-flown in FSD 2 in spring 1986, and the first production Harrier II to include it as standard fit was the TAV-8B referred to above. In prospect is the installation of special navigation and attack equipment to give the aircraft a night-time capability (due to be tested in late 1987). The aircraft will be fitted with a forward-looking infra-red (FLIR) system, and night-vision goggles will be provided for the pilot, with cockpit lighting suitably adjusted. AV-8Bs modified in this way are expected to be available from 1989. It is also reported that studies are well advanced for a dedicated ship-based Harrier II, presumably armed with anti-ship missiles like Harpoon. However, the obvious missing item at the moment is a multi-mode (air-to-air/air-to-ground) radar system, and whilst there are apparently no firm plans to introduce such equipment to the AV-8B airframe, the AN/APG-65 set fitted to the F/A-18 Hornet could have its antenna reduced in size to suit. Such a capability could prove irresistible in the years ahead.

STRUCTURE

Although the AV-8B retains the basic layout and general shape of the original AV-8A Harrier – indeed, from some angles it is difficult to distinguish between the two aircraft, especially in the air – it is really a brand new product. In terms of its structure, the main objectives of the programme have been to increase the strength of the airframe whilst severely restricting weight gains, to extend fatigue life (to 6000 hours), to improve reliability and to reduce the maintenance costs, and the upshot is that only 5 per cent of the original Harrier design, probably some of the after fuselage construction, is carried through.

The highlight of the manufacturing process has undoubtedly been the introduction of a very sizeable proportion of composite materials. Components so produced are formed by combining carbon fibre (which in its virgin state looks like so many rolls of linen) with epoxy resin, cutting and shaping it and then heat- and pressure-treating it in an autoclave. The resulting components are lighter than aluminium parts (and somewhat less expensive) but stronger than steel. Other advantages of carbon fibre (or graphite/epoxy) composites are their resistance to corrosion and fatigue, and their ready repair either by bolting or bonding.

Virtually the entire wing is of carbon fibre construction, only the leading-edge strips and wing-tip components being of aluminium, with some titanium worked into the flaps adjacent to the hot engine exhausts. The multi-spar torque box is of graphite/epoxy, giving the wing a good deal of reserve strength and high resistance to battle damage, and the use of composites in the skinning allows a little more latitude in the way of aerodynamic tailoring than is possible with conventional metal materials. The semi-monocoque forward fuselage is also made up of graphite/epoxy components, the moulded side panels being integrally stiffened and simply bolted on to the cockpit pressure bulkheads and floor. The configuration of the centre fuselage closely resembles that of the Harrier I,



Left: Starboard aspect of the AV-8B's nose, with protective covers over the lens of the Hughes ARBS (see pages 28–29) at the tip, the pitot tube and, above this, the incidence vane, each with its safety tag. The nose cone is removable for maintenance. **Below:** The one-piece, 'bubble' type sliding canopy. The pilot's eye level is raised some 10in compared with the AV-8A, and it is now possible for him to see the wing tips when flying the aircraft; vision angles are quoted as 17 degrees over the nose and 58 over the side for pilots of average stature. Note the rear-view mirrors on canopy frame.

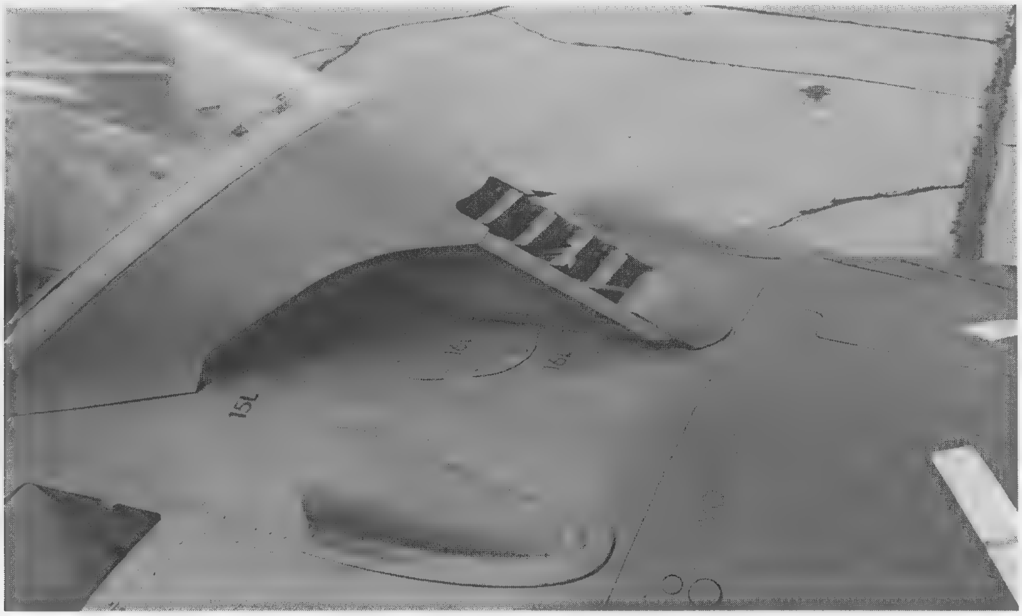
its contours more or less dictated by the presence of the Pegasus engine, but the rear fuselage has been strengthened, and lengthened to accommodate an enlarged equipment bay. The tail fin is also bigger compared to that of the older aircraft.

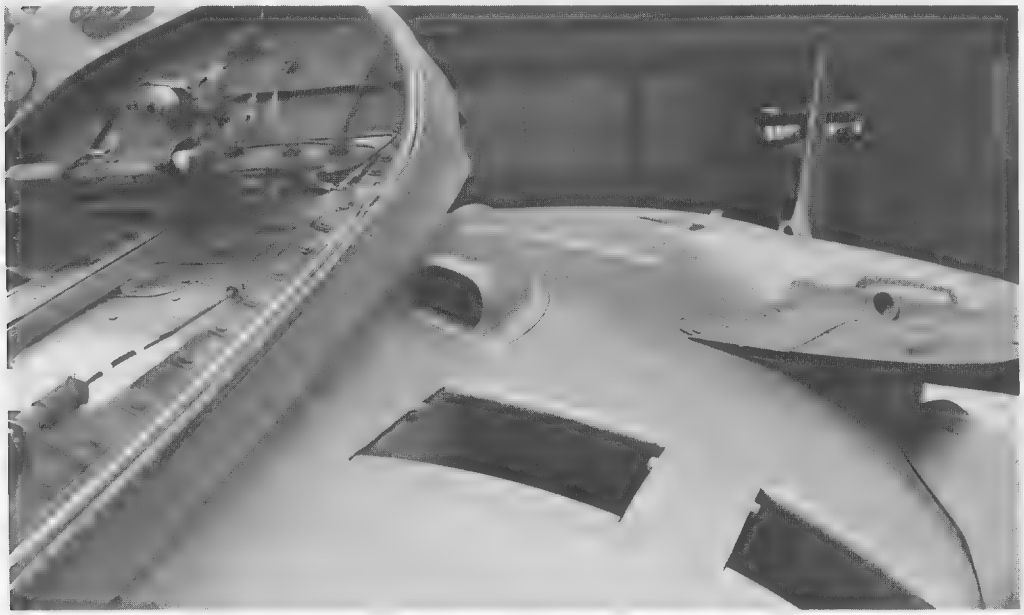
The main undercarriage gear, whilst beefed up, is little changed in general appearance, but the outriggers have been redesigned to reduce their track (making life easier when AV-8Bs are manoeuvred around assault ships and allowing narrower off-base operating strips to be used) and given streamlined fairings in which to retract. moreover, the nose and outrigger wheels themselves are now made of aluminium instead of magnesium. The air brake beneath the rear fuselage is retained. Further forward, the giant LIDs for capturing ground-reflected gases during vertical ascents and descents are boxed off at their front ends by a forward-retracting fence.

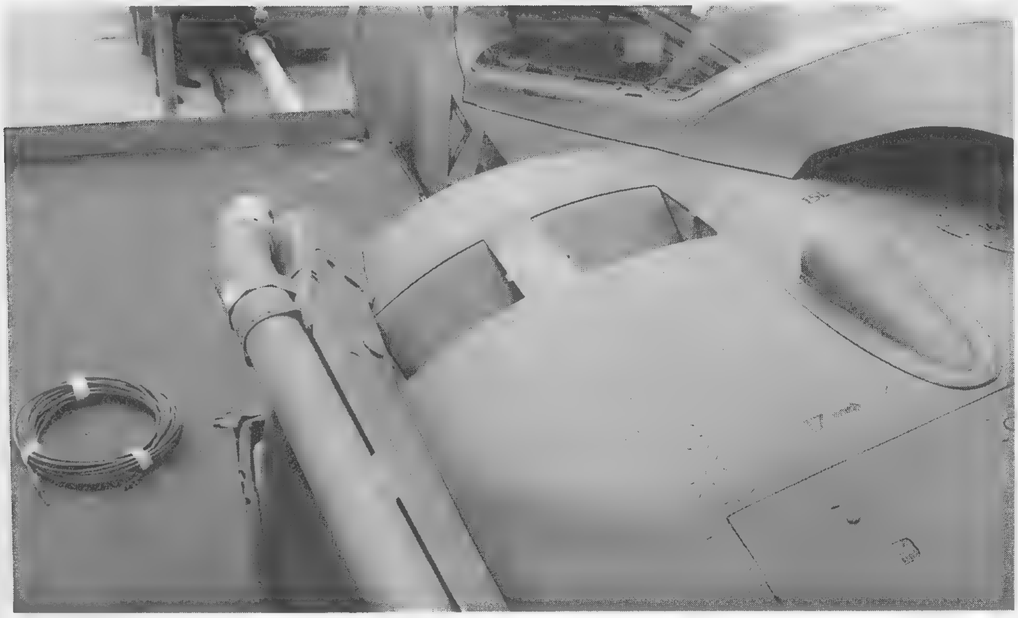
Flight control surfaces comprise ailerons outboard, 'positive circulation' flaps inboard (they utilise to the fullest advantage the gases streamed out by the adjacent engine nozzles), a powered rudder and all-moving horizontal stabilisers. The ailerons droop automatically at nozzle angles of 25 degrees or more, and the flaps are also automatically set in concert with nozzle movement. A major advance over the first-generation Harrier is the adoption of a stability augmentation and attitude hold system (SAAHS), developed by Sperry, which makes it much less of an effort for the pilot to line the aircraft up correctly during take-off, landing and transitional manoeuvres from jet-borne to wing-borne flight.

Fuel is accommodated in wing and fuselage tanks to a total capacity of 7,750lb (about 1100 US gallons, depending on temperature), and the four 'wet' pylons are each capable of holding up a 300 US gallon tank. A retractable, bolt-on, in-flight refuelling probe is available for fitting on top of the port intake, whilst the main fuelling point has been moved up to the front nozzle area, allowing top-up with the engine running.

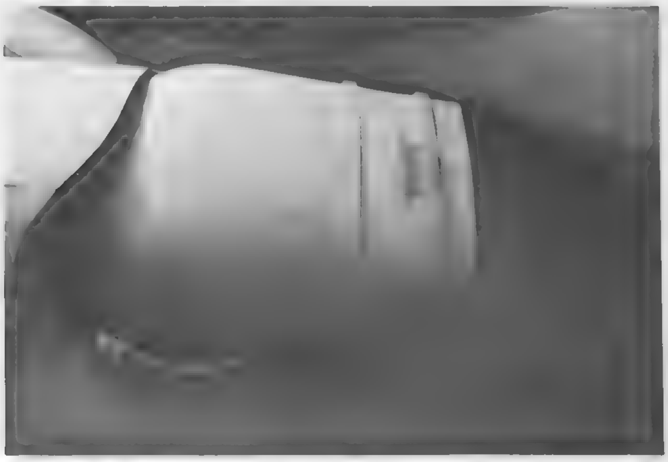
Left: View over the windshield, showing ram air intake on screen fairing (for cockpit ventilation), yaw vane indicator and, further forward, the upper IFF blade antenna.
Below: The Harrier II is well equipped with electroluminescent formation lights as an aid to night-time station-keeping; two strips, for example, are located low each side of the forward fuselage, as shown. Removable nose panels provide access to the aircraft's ASN-130 inertial navigation system (INS) and air data computer, located beneath the cockpit floor. All warning symbols are in black.

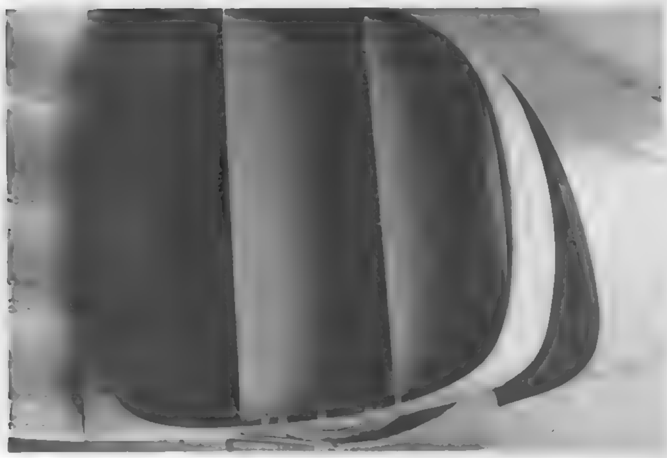


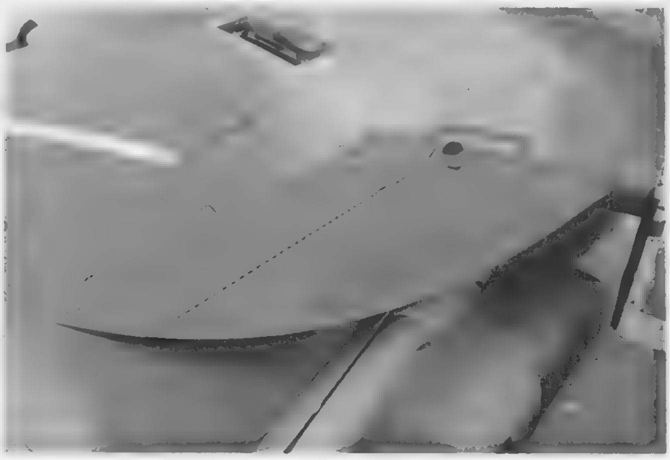


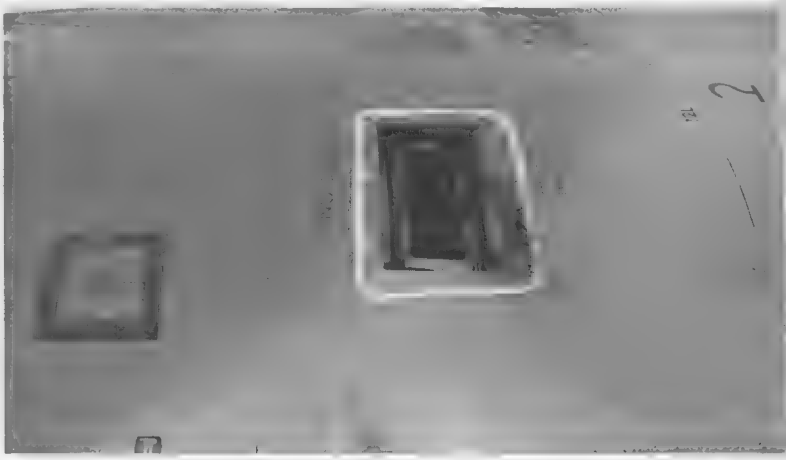


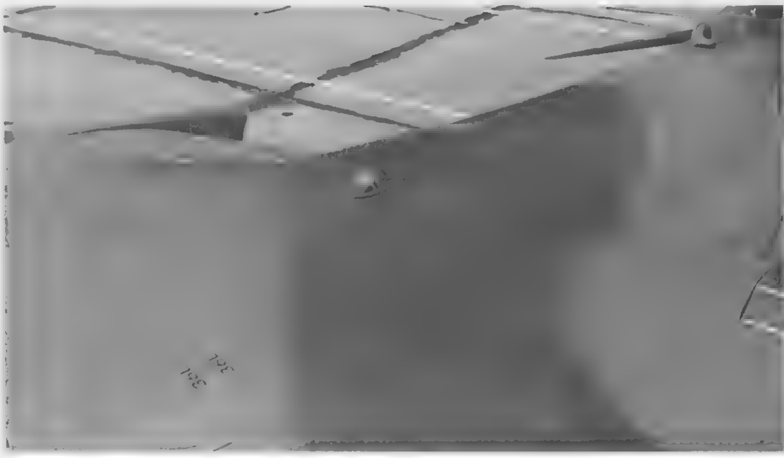
Left top: Top of fuselage behind cockpit, with canopy in closed position, showing the two intake scoops for air conditioning.
Left centre: Same area with canopy slid open, viewed from forward and showing some of the fittings on the canopy back ledge.
Left bottom: Overhead view of port main intake, showing two of the auxiliary inlet doors (open under gravity) and the bolt-on in-flight refuelling probe (in the retracted position). This photo shows especially well the virtually lustreless finish of the paintwork when factory-fresh; in service, maintenance of the airframe, constant cleaning and the effects of the weather will gradually give it a sheen.
Opposite page top left: Looking into the port main intake; those familiar with early Harriers will note the differences straightaway, especially the absence of a central fairing to the compressor face and the shallower curve of the inlet wall.
Opposite page top right: Two views of the forward, 'zero-scarf' engine nozzles and their aerodynamic fairings; these photos also show the size and position of the fuselage national insignia as carried on USMC Harrier IIs.
Opposite page bottom left: The complex contours of the fuselage side, with the starboard front nozzle dominating this photo and the fairing for the rear nozzle beyond. At the top left can be seen the oil drain/vent protective cover, whilst at bottom right is the vent for the forward flank fuel tanks.
Opposite page bottom right: The port (upper photo) and starboard 'hot' nozzles, little changed in configuration from those installed on the first-generation Harrier. Air bled from the engine is used to drive a motor linked to the nozzles via a gearbox and shaft arrangement, ensuring that swivelling takes place precisely in unison. Ribbed titanium shields behind the rear nozzles protect the fuselage skinning from the hot exhaust stream during forward flight.











Above: The addition of leading-edge wing-root extensions (LERX), more or less at the insistence of the RAF, gives the Harrier II a much improved turn rate in the air. They are quickly detachable, to allow the access doors to the engine systems and gas turbine starter/auxiliary power unit (GTS/APU) to be swung open. Note, in the photo above left, the port-side cross-over formation light; the APU exhaust is shown above right.
Right: Fuselage upper surfaces, showing dorsal, strobe-type anti-collision light.
Below: General view of rear fuselage, port side. The ventral air brake is deployed.
Opposite page: Views along the top of an AV-8B, showing the complex wing-to-fuselage fillet arrangement at the trailing-edge root. Notice the water filler point just aft of the strobe light; note, too, that the main engine access panels are not outlined in red striping as they are on the Harrier I. The broad-chord trailing edge flaps are seen here to advantage.

Left: The AV-8B's wing is constructed almost entirely of lightweight graphite/epoxy composite material – the trailing-edge flaps incorporate some heat-resistant titanium, whilst the leading edges are of aluminium, which metal is also used for minor structures elsewhere – and as a result offers a weight saving of some 330lb compared to a conventional metal wing of the same dimensions.

Above: The first prototype YAV-8B, engaged in hovering trials at sea, October 1979. This aircraft was rebuilt from a standard AV-8A Harrier, retaining that aircraft's forward fuselage and cockpit canopy. *McDonnell Douglas*

Below: The second full-scale development (FSD) Harrier II, in its striking colour scheme of red, black and gold, April 1982. This pre-production aircraft was tasked primarily with testing the structural integrity of the airframe and engine/intake/fuel systems. *McDonnell Douglas*

Left, top: The fourth FSD Harrier II was painted up in a pale grey scheme, with virtually invisible national markings and 'Marines' legend; it is seen here in June 1983, during its maiden flight. *McDonnell Douglas*

Left, bottom: A brand new production AV-8B (actually aircraft No 25) on the ramp at McDonnell Douglas's facility at St Louis.

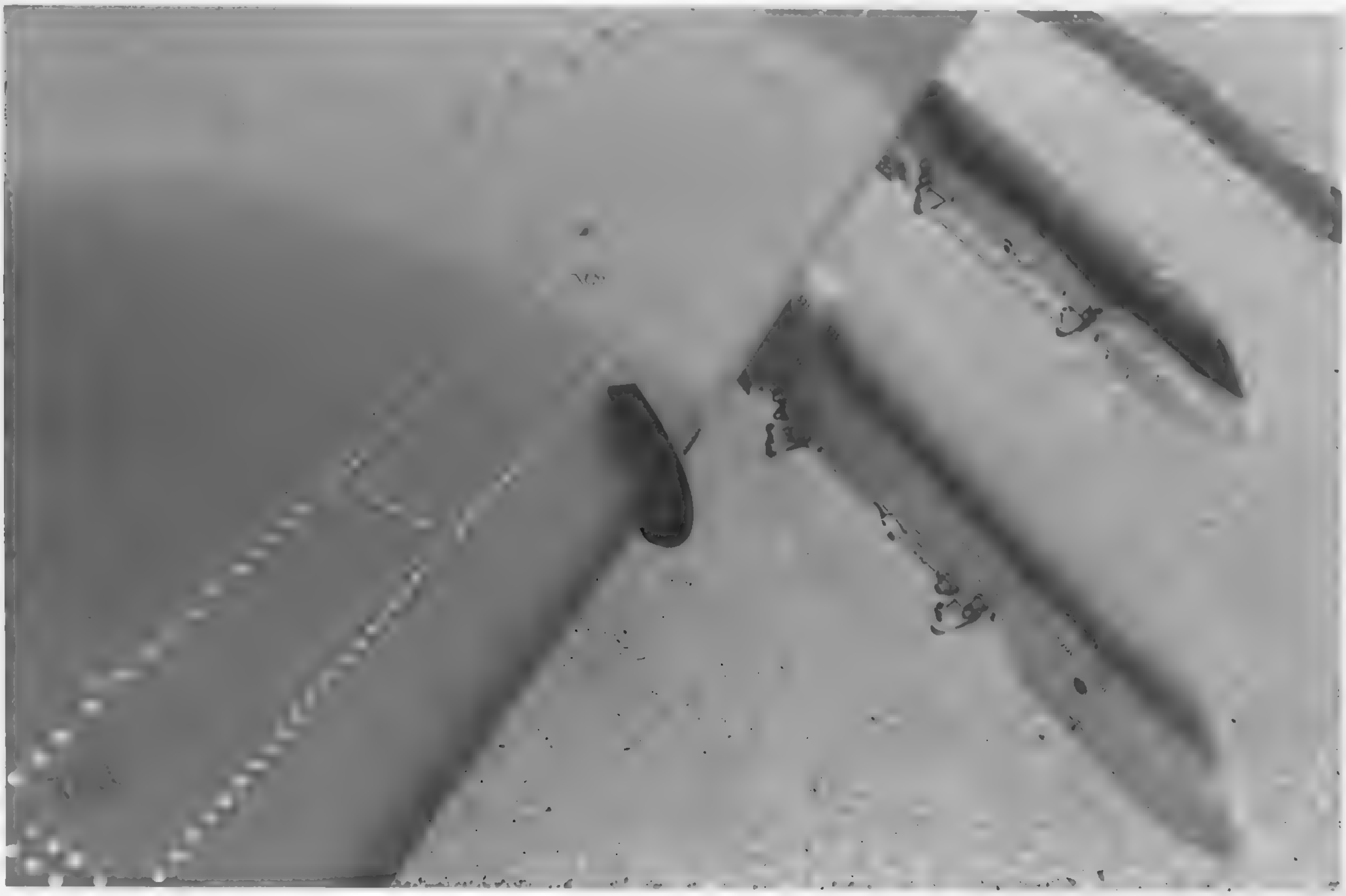
Above: The same aircraft, seen from the other side. The ejection seat has been covered with a protective shroud.

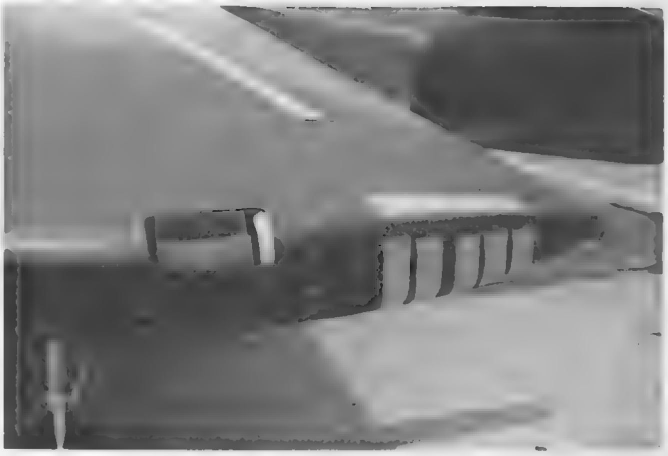
Below: FSD 3 flew for the first time in April 1982 and was used principally for avionics and weapons integration trials and evaluation; later, it had a parachute canister fitted at the tail to enable it to carry out spin tests. *McDonnell Douglas*

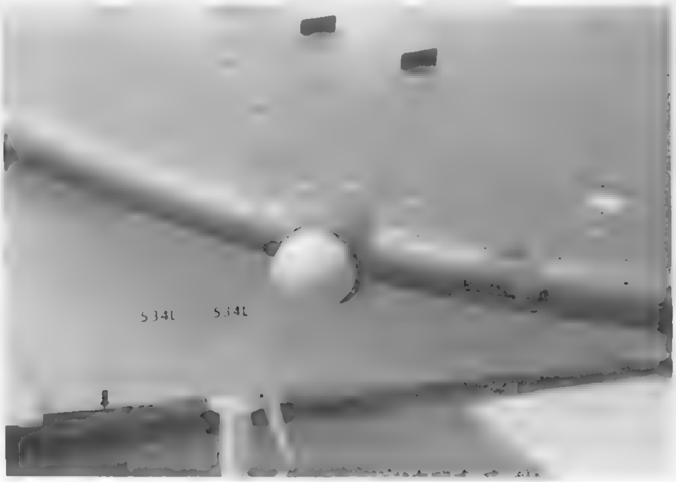
Above: Early production AV-8Bs, like the example shown, retained the double row of auxiliary 'blow in' doors on their intakes but were quickly modified when service evaluation pointed up the desire for alterations to the main inlets to improve airflow characteristics. *McDonnell Douglas*

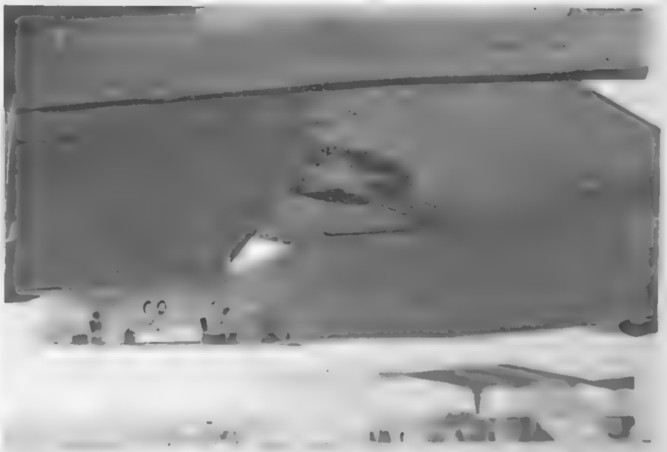
Below: A mid-1985 view of a definitive AV-8B undergoing manufacturer's flight testing at St Louis. The aircraft has the new 'wrap-round' camouflage scheme. *McDonnell Douglas*

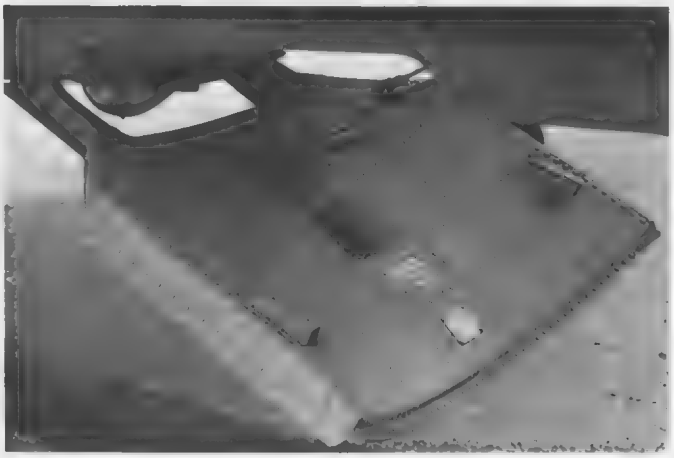
Right: Five photos depicting wing details of a production AV-8B, including the mid-span fence, wing-tip radar warning receiver (RWR) fairing, navigation light and reaction control valve (RCV), plus formation lights (taped over on this aircraft). Note that individual wing panels are numbered, and identified left or right.

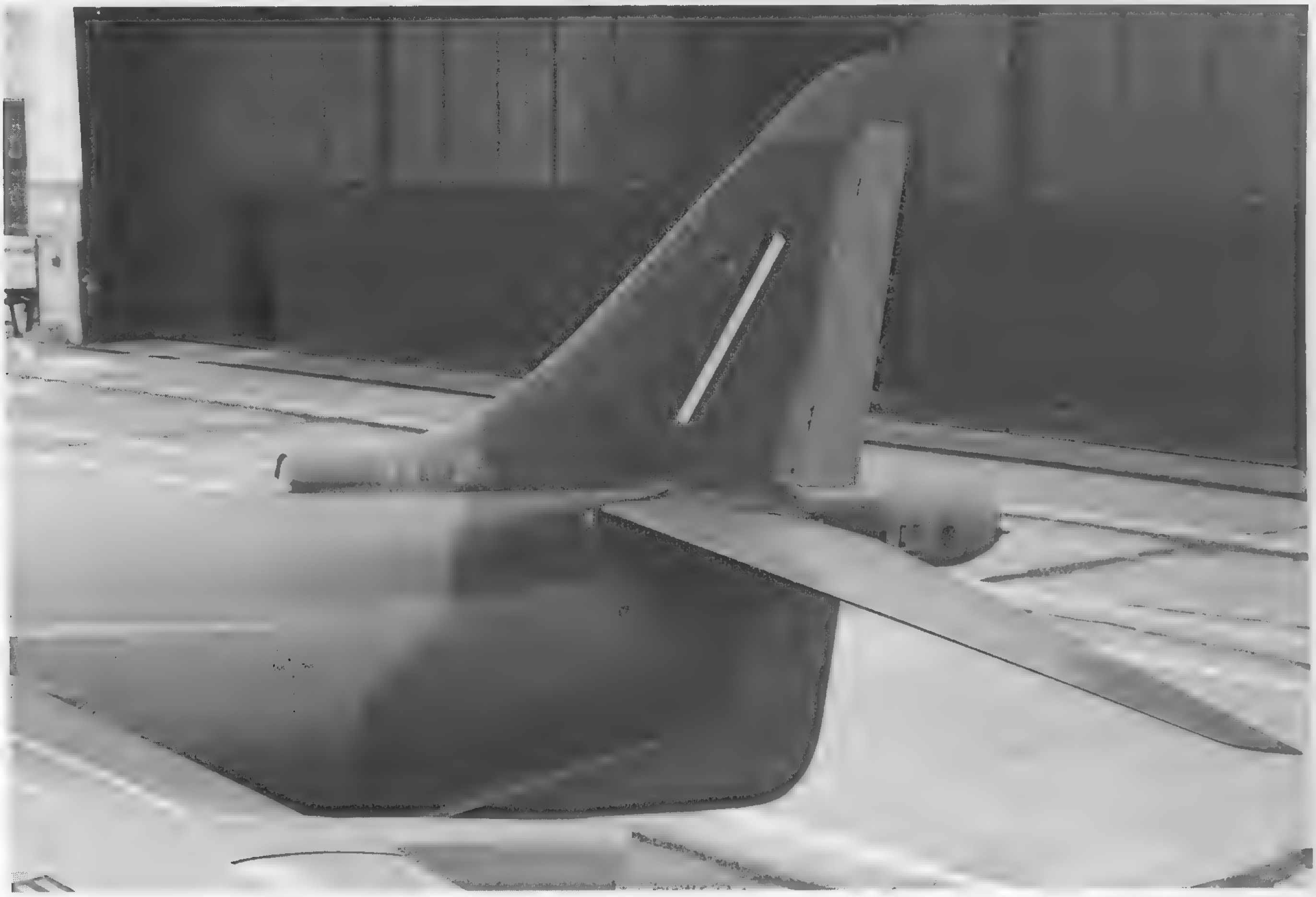




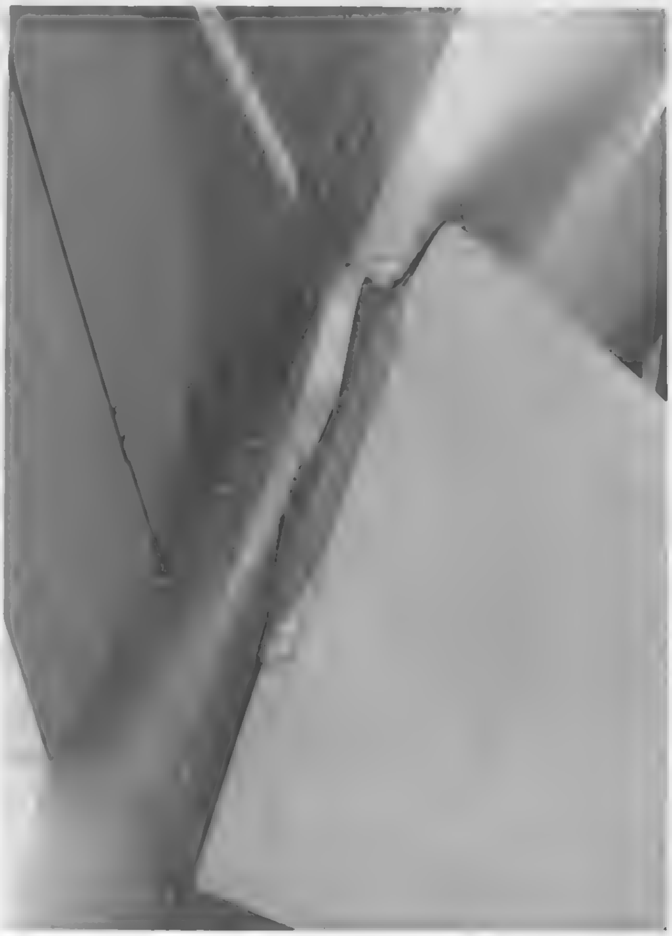


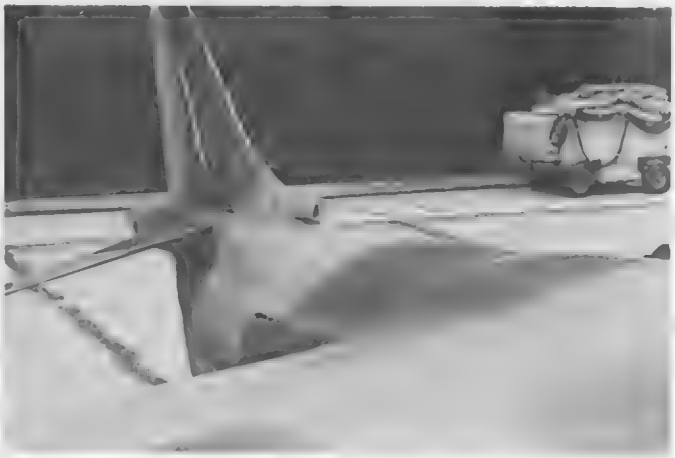


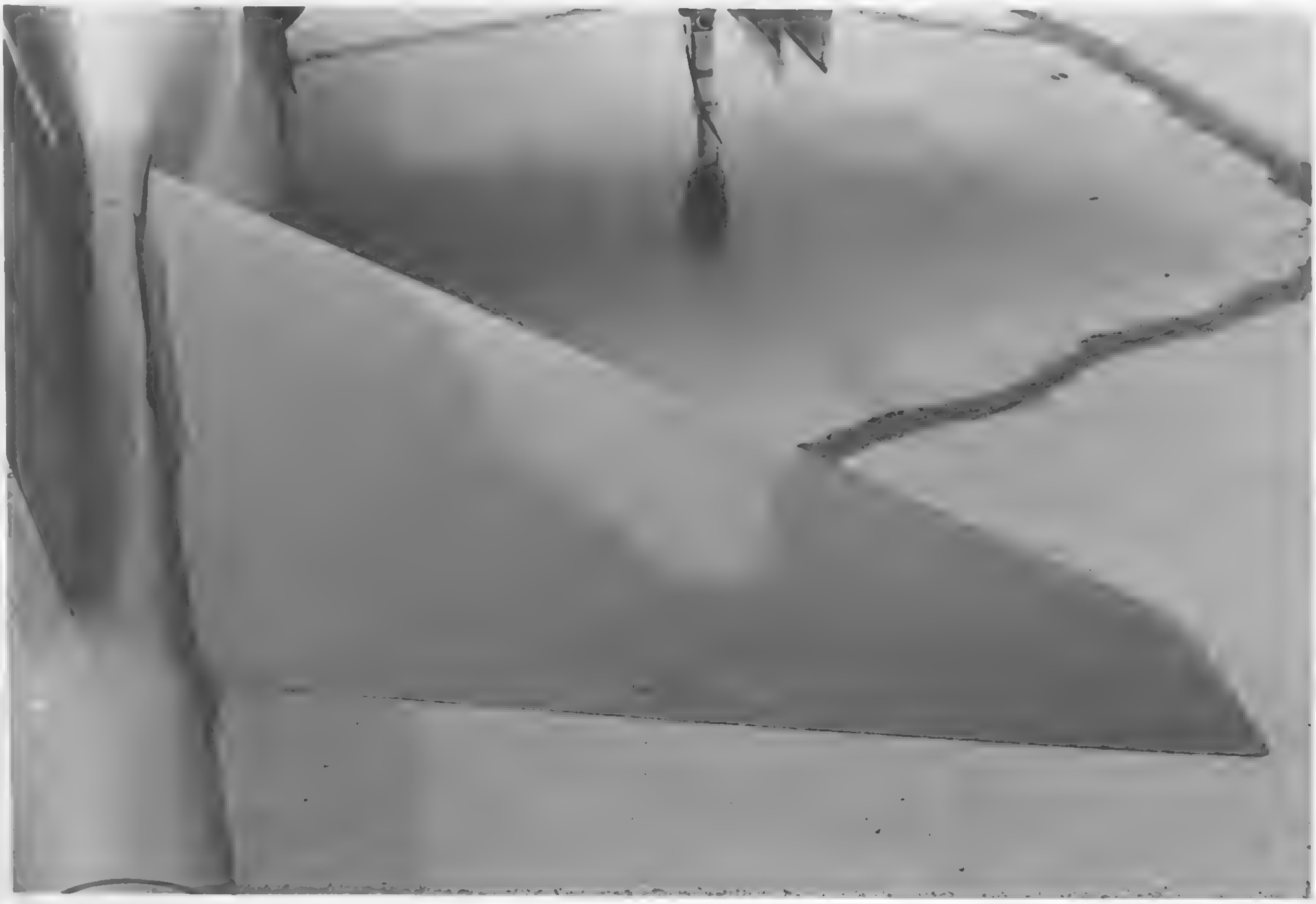


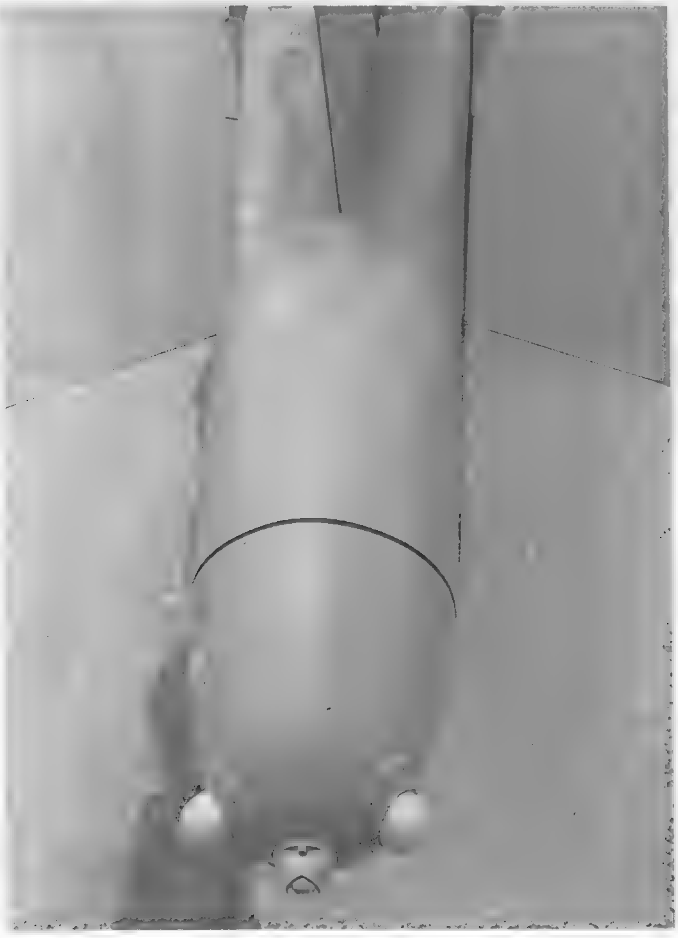


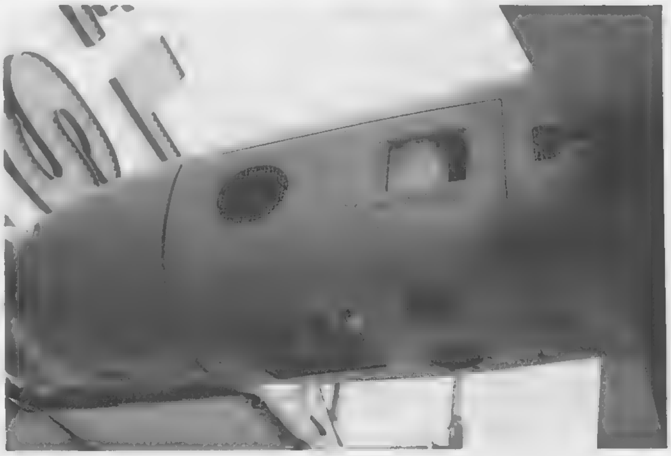
Opposite page top: Close-in study of the ventral strakes, or LIDs. These fittings were developed following extensive experimentation to see how best the nozzle efflux could be controlled for optimum 'ground effect' during vertical ascents and descents.
Opposite page bottom left: Starboard LID. The strakes are removed when the 25mm gun system needs to be carried.
Opposite page bottom right: Two photos showing details of the air brake, with chaff/flare dispenser further aft.
Above: General view of tail, port side; the manufacturer's airframe number is temporarily stencilled in white near the ram air cooling intake at the base of the fin.
Below: Detail beneath the port stabiliser, the effects of the exhaust stream already evident on this brand new AV-8B.
Right: The Harrier II fin is of aluminium construction, with a graphite/epoxy rudder; the tip encloses UHF/VHF and L-band antennas. Fitting near leading edge is a temperature sensor.





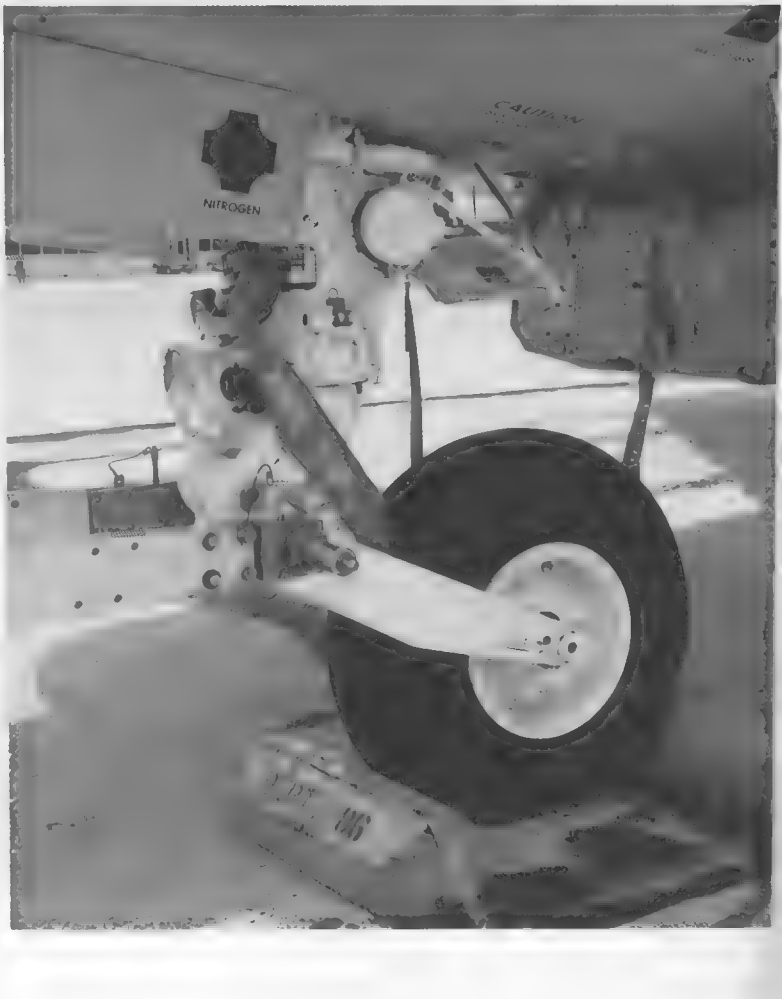






Opposite page top left: Starboard horizontal stabiliser pivot point, showing the design of the sealing plate at the root.
Opposite page top right: Two more views of the tail from the starboard side, the formation light prominent on the fin. In the close-up photo, the oval outlet is for the heat exchanger exhaust, and below this is a printed panel giving full details of the aircraft's colour scheme, primers and top coats, with Federal Standard (FS) reference numbers.
Opposite page bottom: Starboard horizontal stabiliser, which is of composite construction with aluminium kick ribs (at the fuselage junction), leading-edge strips and outboard tips. The torque box multispar is integral with the lower skinning, the top skinning being bolted on to this main structure.
This page: Three photos of the tail boom, showing the rectangular reaction control valves (RCVs) and, at the extreme tip, the navigation lamp and the two ALR-67 radar warning receiver (RWR) antenna domes.

This page: Harrier II nose undercarriage gear, with tow bar attached. The gear leg is equipped with landing/taxi lights, main and back-up, and with lash-down lugs, particularly important with the aircraft parked on flight decks at sea. The retractable crosswise LID ('dam') is visible behind the nose gear, whilst the starboard bay door carries a printed panel explaining and indicating the location of the NATO-standard symbols for such things as jacking and fuelling points.
Opposite page: Main undercarriage gear (top left) and outriggers, the latter housed in extended fairings.



MISSION

Marine Corps aviators are trained to support amphibious and ground forces to the best possible effect, and in terms of the AV-8B this assistance will normally take the form of close air support, *ie* short-notice missions against targets situated very near to the troops on the ground. CAS sorties would include flying against predetermined 'hard' targets such as bunkers and armoured vehicles (for which a typical ordnance load might consist of sixteen Mk 82 bombs), hitting predetermined 'soft' targets such as enemy troop concentrations (perhaps with four Rockeye cluster bombs and gun pods), and ground loiter against targets of opportunity (six Mk 81 bombs, two Rockeyes and two Sidewinder AAMs). However, as the accompanying photo shows, the Harrier II has been cleared to carry a very wide range of stores, the choice of which will depend on the type of target and the mission profile needed to reach it.

In addition to CAS, the AV-8B is also capable of interdiction sorties, *ie* strikes against more distant enemy logistics facilities, for example air bases, supply dumps, oil storage depots and communications centres. Generally speaking, the longer radii called for by such missions will require more fuel to be taken up, with a consequent reduction in the weapons load. As an illustration, the aircraft could conduct a STOVL mission against a target 650 miles distant armed with four Mk 83s, gun, a full internal fuel load and a pair of 300 US gallon tanks, cruising a hi-lo-hi profile. Though not designed as a dog-fighter, the Harrier II is also an effective air-to-air combat aircraft, in either the combat air patrol (CAP) or escort role,

for which it might carry four Sidewinders, a pair of tanks and its gun. Finally, for the ferry mission the aircraft can fly unrefuelled for over 2000 miles with four external tanks, or 2500 miles if the tanks are jettisoned when empty.

There are seven stores stations, six wing-mounted and one on the fuselage centreline, giving a combined allowance of 9200lb; four are compatible with AAMs, four with AGMs, five with TERs (triple ejector racks) and two with B75 and B61 tactical nuclear weapons. The gun pods are of a brand new design, comprising a five-barrelled General Electric GAU-12/U 25mm Gatling-type cannon in the starboard pod and 300 rounds of ammunition in the port unit.

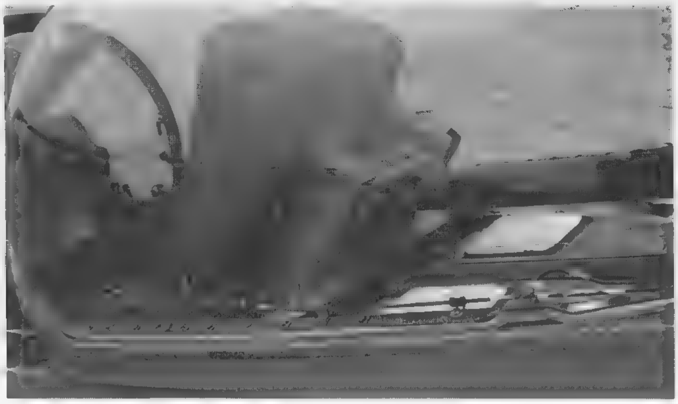
Aiding the pilot is the most modern suite of avionics possible, the key functions of which are navigation, weapons delivery, electronic warfare and communications. The Hughes Angle Rate Bombing System (ARBS), a television/laser-tracker, is linked with a mission computer to give single-pass accuracy in an attack. The heart of the navigation system is a Litton AN/ASN-130 INS. Information is presented on a multi-purpose display (MFD) with navigation, weapons delivery, radar warning, engine and stores management inputs, with a Smiths Industries head-up display (HUD) and an 'up front' control (UFC) panel located centrally. A very advanced hands-on-throttle-and-stick (HOTAS) system permits the pilot to release the aircraft's weapons, select the displays and operate the SAAHS from the central control stick, and open communications, work the air brake and emergency flaps and designate slew control via the throttle lever.

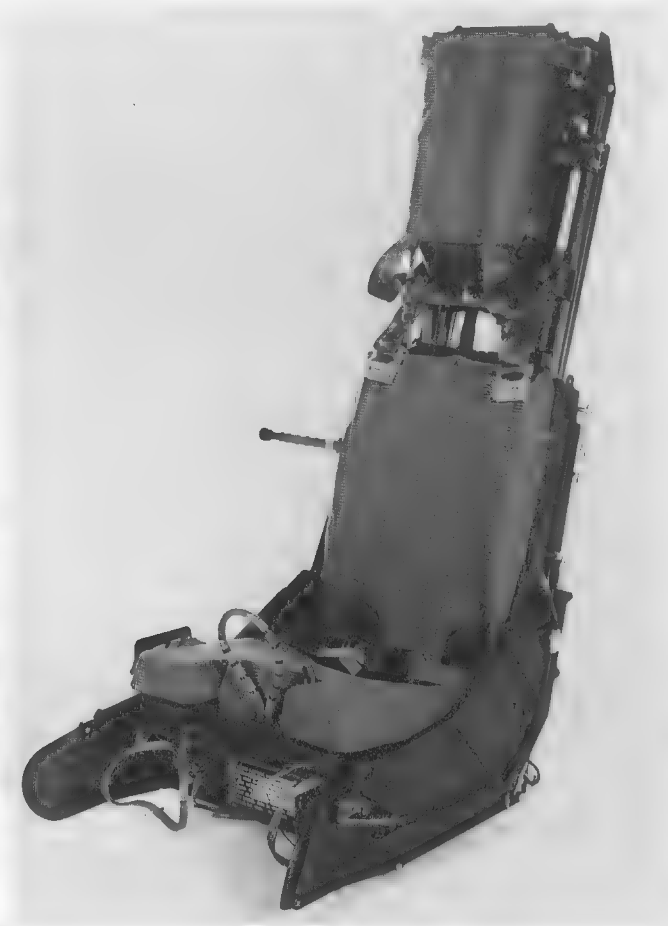
Left: The FSD 3 AV-8B posed with a selection of the weapons for which the aircraft has been cleared. From the foreground, the ordnance shown comprises four AIM-9L Sidewinder AAMs (with practice/acquisition rounds on the left); six 216lb LAU-68 and four 577lb LAU-10 rocket launchers; six 542lb LAU-61 and four more LAU-68 launchers; six further LAU-10s and four more LAU-61s; ten 520lb Mk 77 napalm fire bombs; ten 490lb Mk 20 bombs; fifteen 270lb Mk 81 'iron' bombs; sixteen 530lb Mk 82 'iron' bombs and a triple ejector rack; six 985lb Mk 83 'iron' bombs; and four further TERs. Maverick, Paveway and other 'smart' air-to-ground ordnance can also be carried. For convenience, bomb weights are generally quoted in rounded figures, Mk 82s usually being referred to as 500lb bombs, Mk 83s as 1000lb, and so on. *McDonnell Douglas*

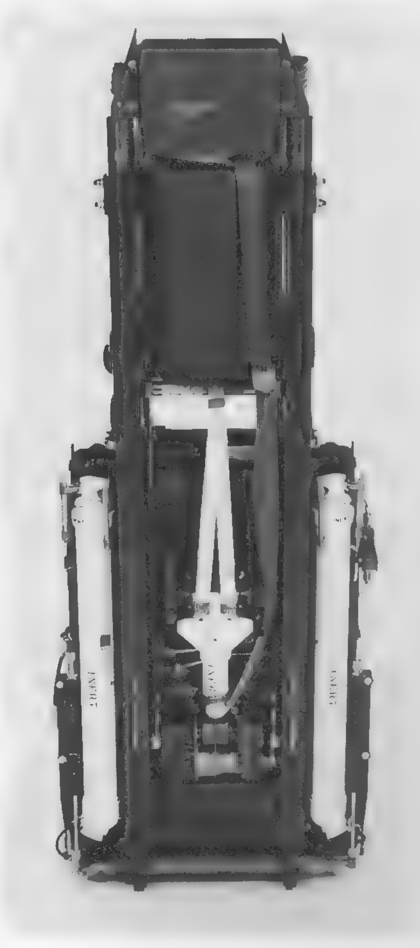
Right top: FSD 3 aloft, with twelve inert Mk 82s carried on TERs during weapons trials, December 1982. *McDonnell Douglas*

Right bottom: A production AV-8B climbs away with six Snakeye retarded bombs carried on TERs on the centre wing stations. The aircraft is also fitted up with its 25mm gun system, the weapon itself being installed in the starboard underfuselage pod and the ammunition in the port-side pod. Rate of fire is quoted as 3600 rounds per minute. The pods replace the LIDs but are fitted with narrow strakes themselves and maintain the 'ground effect'. *McDonnell Douglas*

Above: The three AV-8B port wing stores pylons, with each fitting identified for carriage and wiring.
Right: A glimpse into the cockpit of a production AV-8B. The up-front control (UPC) is at the top centre of the main panel; partially obscured, left, is the multi-function display (MFD).
Opposite page top left: Two more photos showing cockpit details, the upper picture illustrating the Smiths Industries SU-128/A two-glass HUD and the lower the area immediately behind the ejection seat. All the essential controls for weapon aiming and delivery and sited on the throttle and control stick, and all necessary symbology and steering cues are displayed on the HUD, so the pilot need not take his eyes off the target when launching an attack.
Opposite page top right and below: Three views illustrating the SIIIS-3AV8B ejection seat as fitted to US Marine Corps Harrier IIs.
Stencel Aero Engineering Corporation







SQUADRON SERVICE

The AV-8B is destined to replace not only its direct predecessor the AV-8A/C but also the A-4M Skyhawk (see AEROGUIDE 14) in Marine Corps light attack squadrons. At present, activity is concentrated on the US East Coast, at MCAS Cherry Point in North Carolina, where Marine Air Group 32 (MAG-32, part of the 2nd Marine Aircraft Wing) is introducing the aircraft to service.

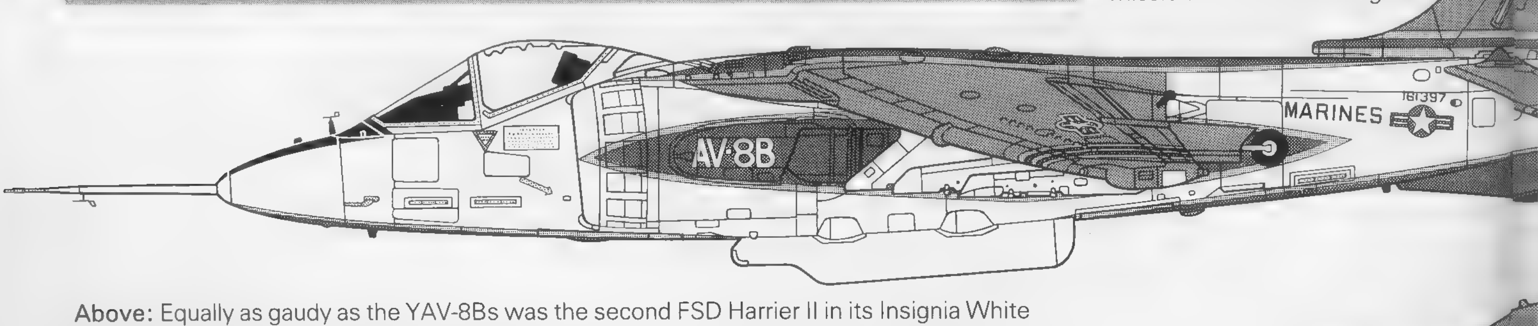
The first production Harrier II was issued to VMAT-203 (tail code 'KD'), the AV-8B training squadron, in January 1984, and just over a year later the first operational squadron, VMA-331 'Bumblebees' (tail code 'VL' – appropriate!), achieved initial operational capability. The next unit, VMA-231 'Ace of Spades' ('CG'), began to work up in September 1985 and attained IOC in July 1986 just as VMA-542 ('CR') started to come on line. The fourth operational squadron, VMA-223 'Bulldogs' ('WP') was expected to achieve IOC early in 1987, followed by VMA-513 ('WF') at Yuma, Arizona. Eight front line AV-8B units, each of twenty aircraft, are currently envisaged, the remaining squadrons being destined for Fleet Marine Force Pacific (FMFPAC) duties.

The TAV-8B trainers should start to equip VMAT-203 later in 1987, at first supplementing and subsequently replacing the older TAV-8As used for conversion training at the moment.

By the end of the 1980s it is anticipated that the US Marine Corps will have an all-V/STOL light attack force, achieving the goal it set itself more than a decade ago. The phasing in of the new aircraft is said to have gone extremely smoothly.

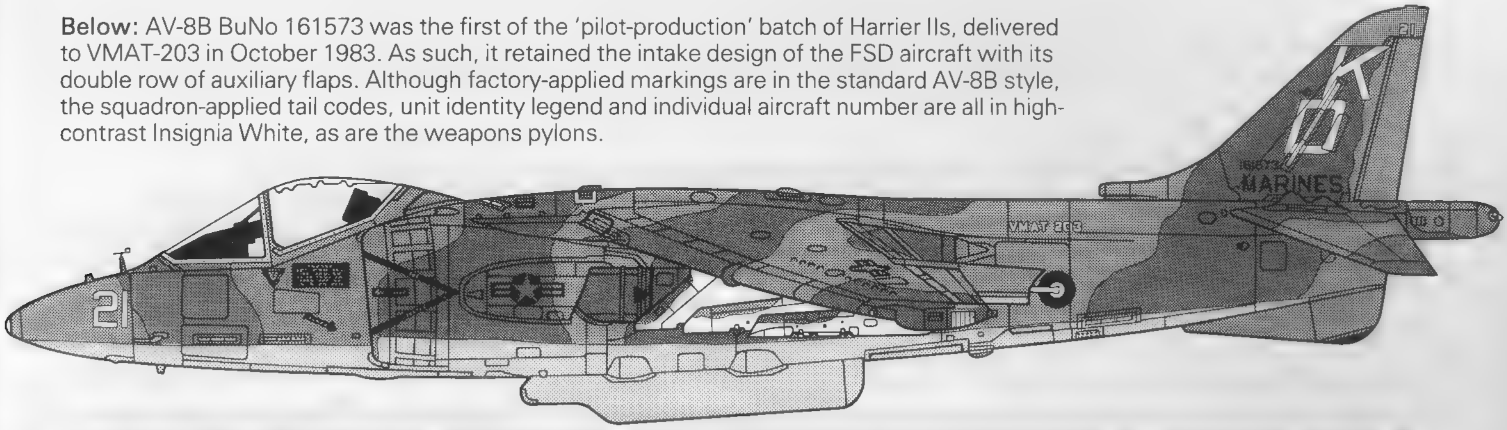
Above: A December 1984 photo showing four Harrier IIs of the training squadron VMAT-203 on a weapons trials sortie. About eighty pilots a year are being trained by this unit, the eventual aim being some 450 fully qualified 'drivers'. *McDonnell Douglas*

Left: VMA-331 was the first Harrier II squadron to become operational, early in 1985. Here aircraft from this unit, each carrying a single Snakeye and gun pods, formate during a training mission. *McDonnell Douglas*



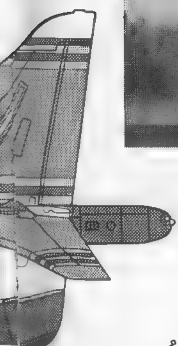
Above: Equally as gaudy as the YAV-8Bs was the second FSD Harrier II in its Insignia White (FS.17925) finish, with Insignia Red (11136) wings and tail surfaces and Insignia Blue (15044) and gold trim. Such schemes aid visual analysis of the aircraft's behaviour during flight-testing.

Below: AV-8B BuNo 161573 was the first of the 'pilot-production' batch of Harrier IIs, delivered to VMAT-203 in October 1983. As such, it retained the intake design of the FSD aircraft with its double row of auxiliary flaps. Although factory-applied markings are in the standard AV-8B style, the squadron-applied tail codes, unit identity legend and individual aircraft number are all in high-contrast Insignia White, as are the weapons pylons.

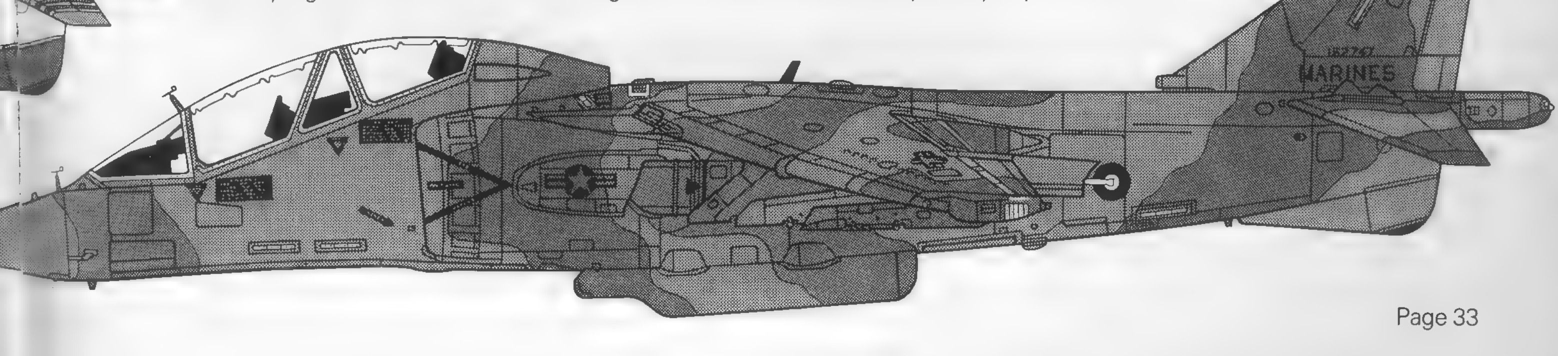


Above: One of VMA-331's aircraft (in fact, that depicted in the four-view drawings on pages 34 and 35), the blink of its dorsal strobe light neatly caught by the camera. *McDonnell Douglas*

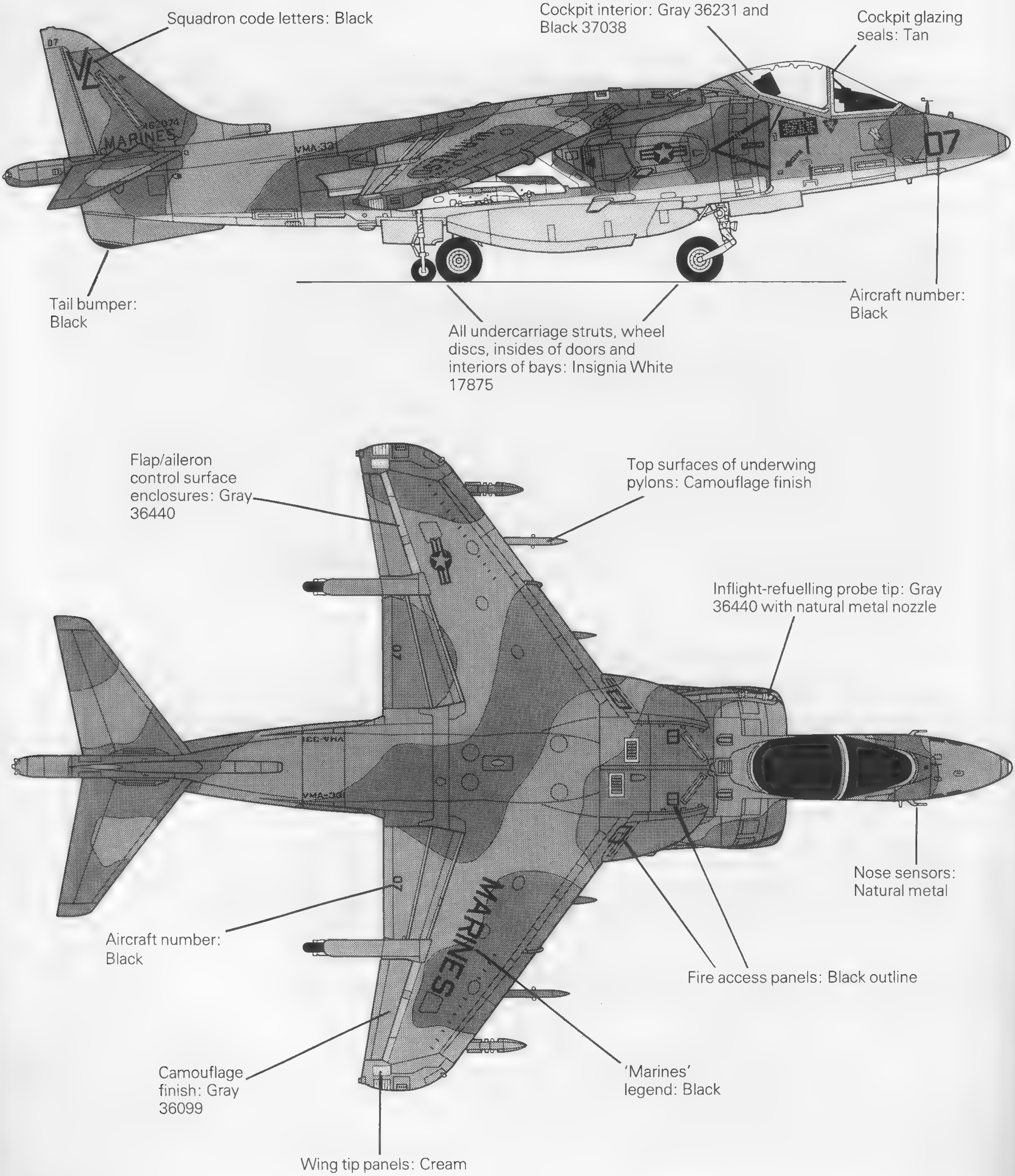
Left: 'KD' on the tail signifies VMAT-203 again as one of the unit's AV-8Bs is seen at the hover. The Harrier II training schedule has been running very smoothly, thanks in no small measure to the high level of reliability demonstrated by both airframe and engine. *McDonnell Douglas*



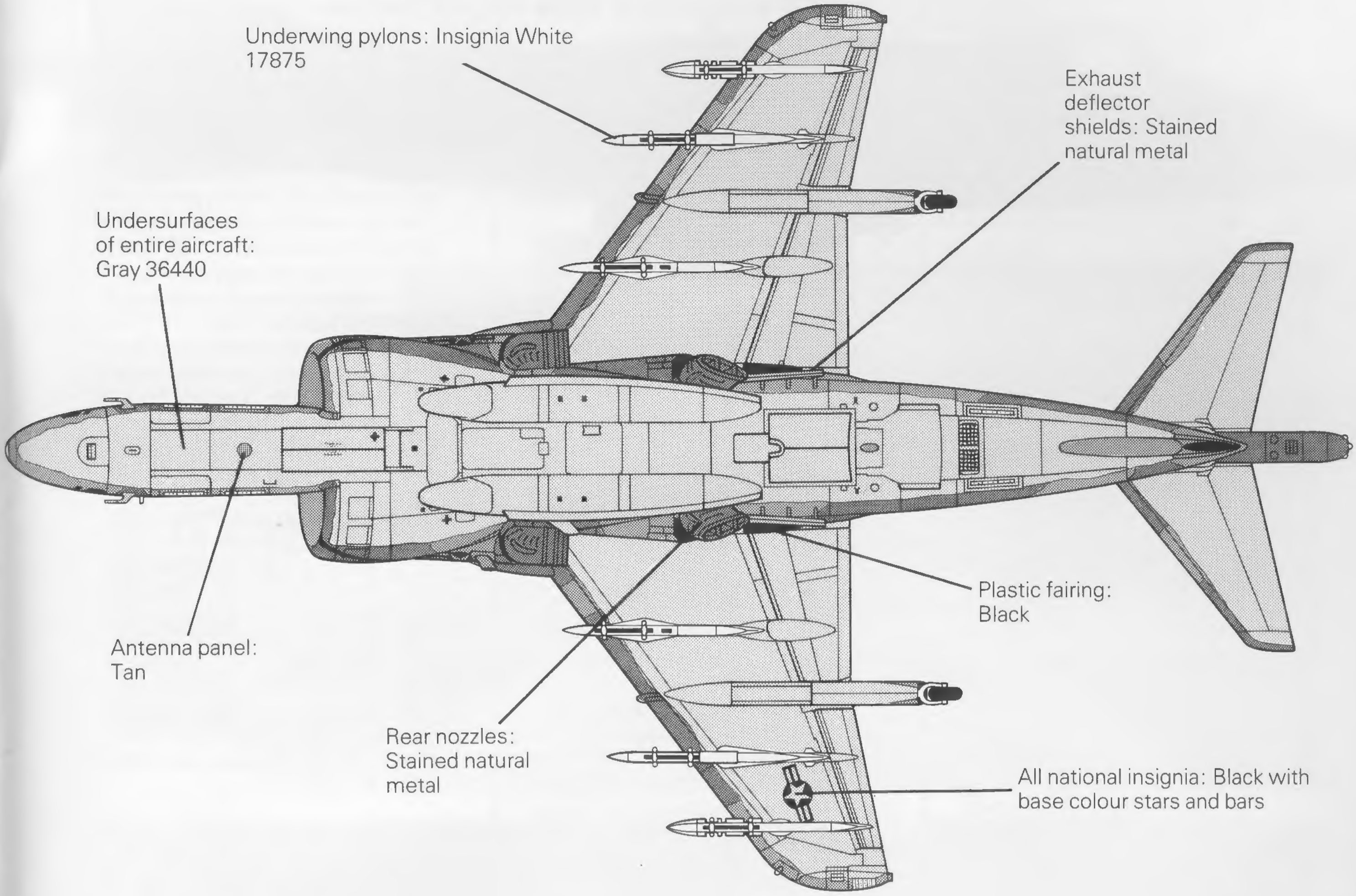
Below: The first two-seat TAV-8B, which went up on its maiden flight late in 1986. The nose boom is for instrumentation purposes only, and will not feature on squadron aircraft. Twenty-eight of these trainers are being built, but the RAF is unlikely to buy any.

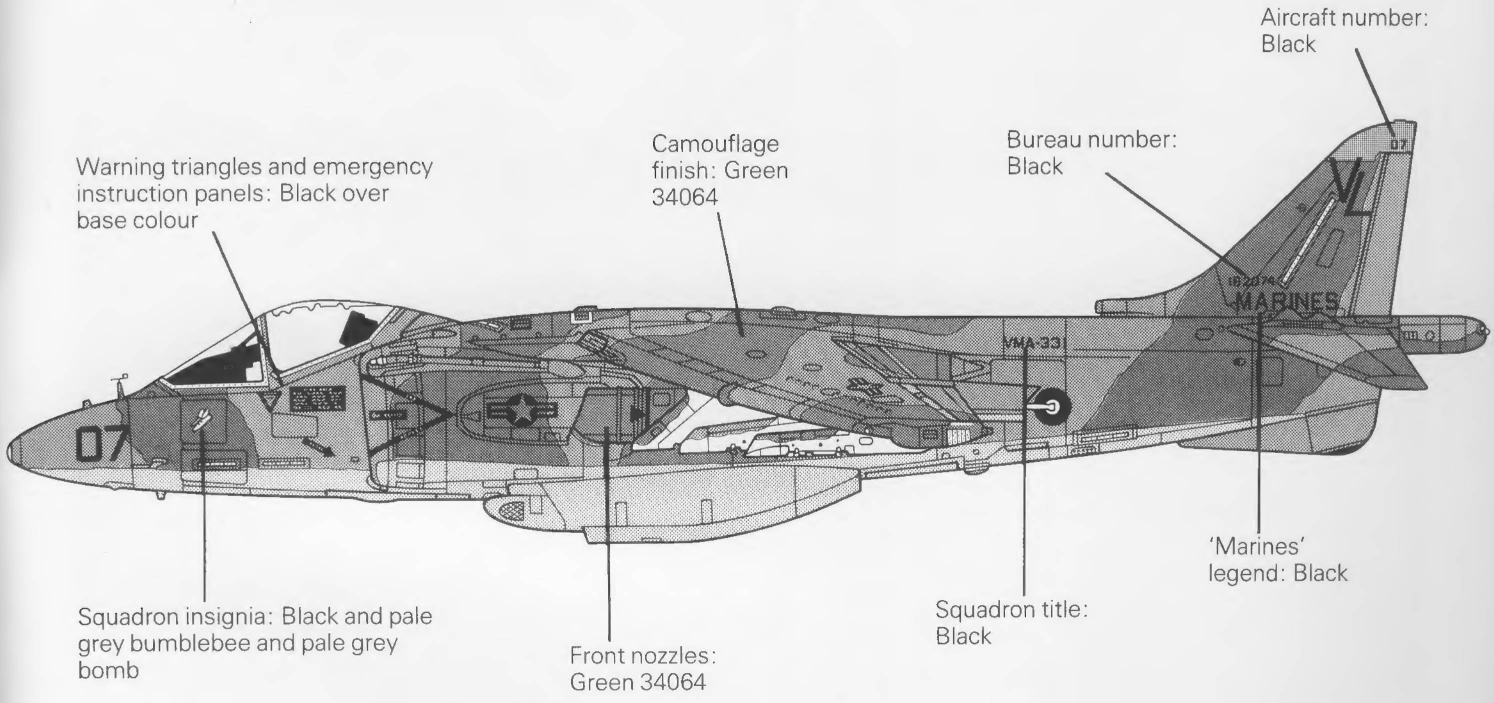


McDONNELL DOUGLAS AV-8B HARRIER II, VMA-331, MCAS CHERRY POINT, 1986

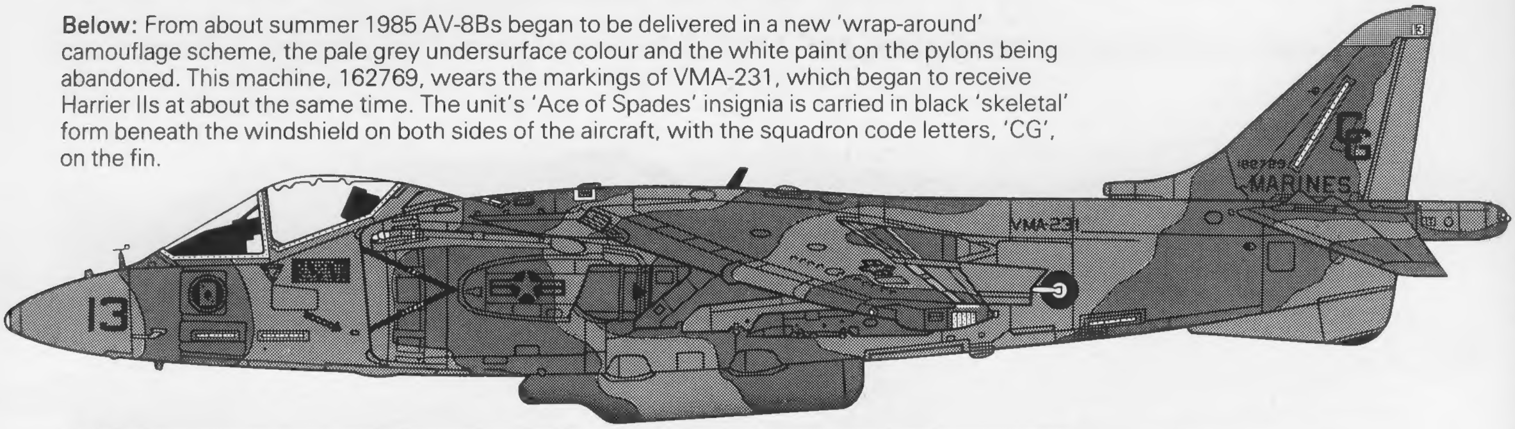


Numbers refer to Federal Standard (FS) 595a listings **1:72 scale**





Below: From about summer 1985 AV-8Bs began to be delivered in a new 'wrap-around' camouflage scheme, the pale grey undersurface colour and the white paint on the pylons being abandoned. This machine, 162769, wears the markings of VMA-231, which began to receive Harrier IIs at about the same time. The unit's 'Ace of Spades' insignia is carried in black 'skeletal' form beneath the windshield on both sides of the aircraft, with the squadron code letters, 'CG', on the fin.



Left and below: As in the Royal Air Force, 'Harrying' in the Marine Corps emphasises operations from dispersed sites away from fixed bases, which in time of war would be located as near as possible to the forward line of troops (FLOT), to keep call-up time to a minimum, and would also prove very difficult for the enemy to find. The particular relevance of these operations to the close air support mission is readily obvious, although the detection of 'hot' aircraft by infra-red (IR) systems is a problem. In these photos, AV-8Bs are seen practising V/STOL techniques. *McDonnell Douglas*

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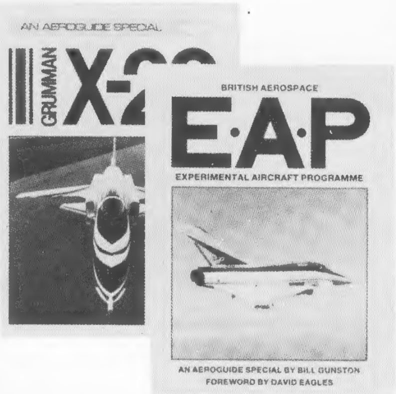

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